INTERPRETING SCIENCE

UNDERSTANDING OUR ENVIRONMENT

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INTERPRETING SCIENCE

UNDERSTANDING OUR ENVIRONMENT

by

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PHILADELPHIA

Book One

THE JOHN C. WINSTON COMPANY
CHICAGO ATLANTA PHILADELPHIA LOS ANGELES TORONTO DALLAS

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Preface

In this series of textbooks for those grades often designated the junior high school grades, the aim is the intelligent participation of the pupil in the world dominated by science. That participation for the pupil is immediate, not at some future date. The content of the series deals with the environment in which the pupil is immersed. Attention is directed to the actual surroundings, and the science is developed from the experience of the pupil. Sometimes the experience that starts an investigation has been common to all the pupils, but often the common experience is provided by experiment. The experience of other observers is drawn upon to supplement present observation.

The horizon is not limited by the neighborhood in which the pupil finds himself. He is carried afield through the experience of scientific observers and through accounts of scientific developments in industry, agriculture, and exploration, into realms not at present open to his direct observation. Science of the whole unit world is the scope of the study. No limitations of precinct or nation restricts the interest of scientist or pupil. Teachers and parents well know the flights of fancy and the breadth of intelligent questions by young minds. Inspired by actual questions of pupils, this series of books at one time follows and at another leads the pupil's interests to the uttermost nebulae and the stretches of interstellar space. Then the study returns and finds the same laws of science operating in the intimate world about us.

The material content of the series is that body of knowledge generally accepted for the seventh, eighth, and ninth grades by formal courses of study and by tacit agreement. No attempt is made to divide the field among the sciences. A topic or problem is followed after the manner of modern scientific studies across the uncertain boundaries that divide the various domains of the special sciences. The contributions of scientists of different fields are used to help solve a problem, and observations are made with the technique developed in that science which serves the purpose best. Only a general indication of the fields of the different sciences is casually presented to the pupil.

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No wide agreement exists in division of topics among the grades, but such agreement is of no great consequence. In the present series of texts each volume has sufficient breadth of field to allow the selection of topics to fit the local need. The intensive study of an entire volume in a school year is not necessary. A pupil could take only a cursory glance at each unit if he were required to cover the whole field. Omission of selected units or parts of units, or a more sketchy use of the material, is readily possible without destroying the unity and breadth of the scientific interpretation of the pupil's environment. Adjustment of the volumes to local needs is readily made.

Attainment of the pupil's point of view is an aim of modern teaching and modern texts. Who knows the pupil's point of view? The observant teacher of long experience accumulates a knowledge of pupils' mistakes and pupils' questions, where questions are encouraged. Such knowledge may smooth the rough way through a prescribed course of study, but how far a teacher may draw deductions from this evidence as to the pupil's point of view toward the objects and phenomena of his environment is problematic. Certain illuminating studies have attempted to learn the subjects of native pupil interest, but as teachers know full well, "native" interests may be aroused by skilled teaching. "Motivation" is a standard practice to overcome teaching resistance. An objective study of pupils' reaction when freed of the customary restriction of large classes, their interests out of class, the analogy of the teacher's own response when relieved of a course of study, the interests of the "layman," together with the more formal published studies, may furnish each teacher guidance in adapting any text to presentation that coincides with the pupil's point of view. Uncertain as we are of the hypothetical "pupil's point of view," this series of books attempts to use as points of departure the varied and vivid interests shown by living boys and girls.

On educational platforms and in print occasional attempts have been made apparently to belittle the value of teaching the facts of science in favor of teaching the method of science. Yet to the average person as evidenced by response to newspapers and motion pictures, as well as to radio, facts or fictions have more vivid appeal. If in accord with educational theory we use interest as our guide, we should show respect for factual knowledge. A certain body of facts is the substance of knowledge. Scientific thought grows through the absorption of facts. This series uses scientific facts freely. It is not expected that

all facts will be retained by the pupils. Provision is made for the discretion of the teacher and the requirement of local course of study.

The method of science also is kept constantly before the pupil's attention. The method of establishing facts through observation is presented in experimental studies as well as through text narrative and exposition. The organization of facts into a body of knowledge, their interpretation in a generalization at the pupil's level, the use of such generalization in the interpretation of facts in a new situation, the framing and testing of hypotheses, receive attention at strategic positions. Didactic instruction in the method of science, akin to propaganda, has a use in impressing the value upon the pupil. Illustration of the method in use and insistence upon its use within the ability of the pupil, make it function in his present life. In this series the method of science is presented directly at appropriate places. The solution of problems by scientists illustrates the method in use. Guidance in its use in the solution of problems provides opportunities for its exercise.

A recurrence of facts through the series and within the book provides the opportunity for amendment and expansion of concepts previously formed, an essential characteristic of scientific thought. Refreshing of fact and its refitting into new situations is a time-tested practice of teachers. Knowledge grows. Too often it has been treated as static, to be learned wholly and at once. As in life and in science, so in this series of texts, facts are added to previously known facts, principles are developed in accordance with new facts, concepts evolve. The pupil develops for himself the concept of the changing nature of his knowledge and of all knowledge. Unlike the laws of the Medes and the Persians, the laws of science change as the partial nature of earlier statements becomes evident. The discovery of nature's processes must be gradual with the addition of fact to fact. Our statements describing these processes, the laws of science, must also change and develop. The man-made laws of science are always subject to amendment and repeal on proper evidence. It is necessary that pupils grow to assume this attitude of science.

The open-minded attitude of science is too often not apparent in textbooks or among teachers of science or even among research workers. The teacher of science must be ever on guard to avoid ex cathedra pronouncements of finality. It seems sometimes to have been assumed that an attitude of skepticism is not to be tolerated in elementary treatment of science. Many observant teachers agree,

however, that in the minds of pupils, science speaks with no less authority because it cannot speak the final truth. An attitude of suspended judgment when evidence is insufficient and a willingness to revise earlier findings are cultivated through this series.

The necessity of establishing basal facts through observation is brought ever and anon to the attention of pupils through experimental procedure and textual account. Accuracy of observation is required in suggested experiments. The danger of inaccuracy is told by illustration in the story of the text. The necessity of an "explanation" through natural causes is developed through instances. The pupil's experience as he recalls it, the present experimental experience, and the experience of other observers as related in the text, are used to show the possibility of finding natural causes through investigation. The establishment of a "cause" through sufficient study and adequate evidence is developed.

In these books a unit of study opens with a brief "preview" which permits orientation. Pupils usually, unless "guided" by teachers, omit introductory matter and plunge into the story, just as other readers, including teachers, omit prefaces and turn to the body of the text for information and formation of their own judgments. No great harm is done by such omissions. Indeed occasional assignments are profitably made without guidance. It is important to allow pupils to develop their own powers of navigation through unfamiliar waters, selecting their own courses and arriving at their own ports.

Learning aids at the close of chapters are serviceable for those pupils who have developed a determination to master the course as laid down by teacher or author. Teachers may feel that such aids are seldom used by pupils except under pressure. The teacher's own guidance and testing devices may be substituted for those of the text without doing violence to the course. For those pupils who have attained the power of self-motivation and self-direction as well as self-propulsion, the learning devices will be of service in keeping in touch with the standard requirements. A study of the problem is developed through these study devices for those teachers who care to use them.

The shift of emphasis from class teaching to individual learning is taking place with increased acceleration in some situations, but teachers with several large classes and inadequate facilities, although agreeing in principle are sometimes skeptical of possibilities in their own situations. Class teaching is widely practiced. The books of this

series are adapted for use in environment of class management as well as in those fortunate environments where the individual pupil has an existence other than as a component of a class unit.

Procedure and terminology in these books are reduced to simple terms. Experiments and directed observation are kept within the grasp of pupils of the grade. Experiments require as little laboratory apparatus as possible, and experimental techniques that divert attention from the question of the experiment are avoided. A scientific term is introduced when a concept has developed to the stage where a definite term is needed. Out of deference to the opinion of others as codified in courses of study, terms and topics are introduced which are not deemed essential to the main story of the book. Such introductions are enclosed in brackets. In study directions pupils are directed to consult their teacher for treatment of these sections.

A chapter tells a story without interruptions by study devices or directions for experiments. Advantageous though it may be to interrupt the story to establish a fact by direct observation, teachers know that pupils do not study that way, nor does the management of a large school permit the shift from study hall to laboratory when a question arises in the text. Activities must often conform to the requirements of a roster. Therefore, study suggestions, directions for experiments, and tests are assembled at the ends of chapters. Study suggestions may appropriately be used before the chapter is studied. The directions for experiments may be readily used at the beginning of a study to establish basal facts through observation, or they may be introduced at appropriate points in the text.

Ample provision is made for more extensive work by capable pupils. At the end of each chapter are suggestions for further activities. Spontaneous suggestions by the pupil, however, often serve far better than any printed directions to lead pupils to investigation where interest dictates.

Vocabulary-building proceeds apace with the development of concepts. Suggested pupil-developed vocabularies accompany each chapter. Such vocabularies serve as a summary of concepts, but they are not designed for drill and testing. Tests provided for the use of pupils will aid them in judging the adequacy of their study.

This, the seventh grade book, aims to bring the pupil in contact with selected factors of the world about him. He has made the contact previously but often it has been

meaningless. This text calls freely to mind the common experiences and creates the opportunity for others through experiment and observation. The pupil is led to seek a meaning in terms of science and of influence upon human life. Mud has been mud. Now the pupil is led to see erosion and soil-making with their important consequences to man and other living things.

The author finds it impossible to acknowledge his indebtedness to all those whose suggestions he has used. As a class room teacher he seized an appealing idea or illustration where it has appeared, in reading, in demonstration, in the classwork of other teachers, in pupils' stories of their experiences, in casual observation in field, laboratory, and industry, as well as in serious study. There is no such word as *plagiarism* in the classroom teacher's lexicon. The author wishes he could extend his thanks personally to the many brilliant minds, young and mature, which have made suggestions. He is quite unable to credit the authors of ideas or distinguish the grains of thought, if any, that he may have added. He can only extend his thanks in general terms to the great fraternity of teachers and pupils and invite any who may care to do so to make free use of the accumulated ideas.

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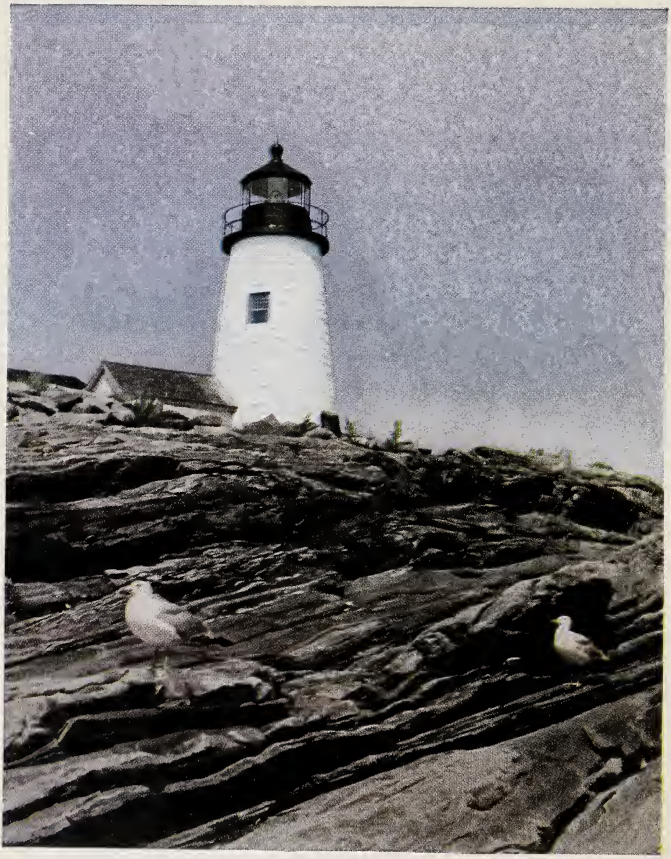
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H. Armstrong Roberts, Phila.

A beacon on a rock-bound coast. Living nature and non living nature meet, and the hand of man seeks control. The bird life, the green plants, the rocks, the sky are fascinating studies for the scientist.



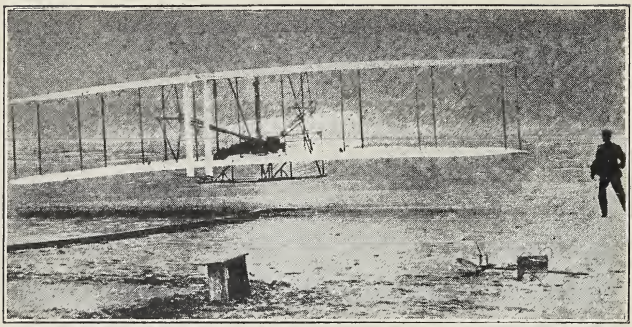
Philco Radio Corp., Phila. *Ewing Galloway, N. Y.*

CHAPTER ONE

A FEW THINGS THAT SCIENCE HAS DONE FOR US

Then and now. You do not see anything wonderful in the little mahogany cabinet from which a human voice or jazz music comes at a turn of a knob. It is just common, everyday experience to turn the dial and hear the famous clock, Big Ben, striking the hours in London, to listen to the crash of the waves on the bow of the ship carrying explorers to the Antarctic continent. You sit in an easy chair by your comfortable radiator and hear the voice of Admiral Byrd at Little America. It is just an everyday experience.

Nothing wonderful? Think a minute. In 1775 when the British marched from Boston to destroy the Americans' military stores at Concord, the quickest way to get the news to the farmers and villagers at Lexington and Concord was to send a messenger on horseback. You all know the story in Longfellow's "Paul Revere's Ride." That was less than one hundred seventy years ago. Even when Longfellow wrote



Wide World Photos, Inc.

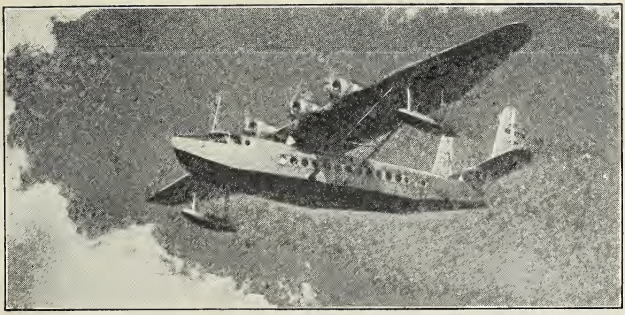
The Wright brothers' first airplane

that poem, in 1860, the telephone had not yet been put into service and the telegraph was new and stations were few and scattered. It was not until 1876 that Alexander Graham Bell sent the first telephone message. Over thirty years later, in 1907, Lee De Forest patented the radio tube. Indeed, your fathers can remember when there were no radios.

In our own day when Japanese aviators dropped bombs on an American gunboat on a Chinese river, all the United States knew it the next morning. A few days later motion pictures of the bombing, taken by a newsreel photographer on the deck of the ship during the attack, were being shown in thousands of theaters throughout the country. It took Paul Revere some three hours to ride the twenty miles from Boston to Concord; today the radio carries a message around the world in less than a second. In Paul Revere's time, how



Rapid transit in the Eighteenth Century. The post rider.



Richard B. Hoit, from Globe

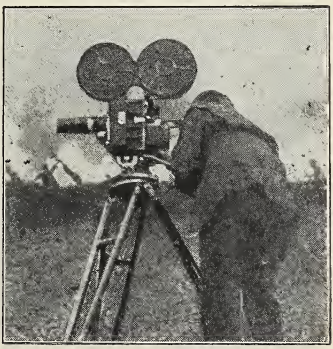
What thirty-five years of development accomplished

long would it have taken to bring the news of an attack on a Chinese river to the people of Boston?

The American Revolution did not happen so very long ago. The father of the author of this book had an old friend who had talked with George Washington. Yet think of the changes in communication that have welded the world together since that time!

In 1787 John Fitch's first steamboat plied the Delaware River. Fulton's *Clermont* steamed from New York to Albany in 1807. On the ocean, steamships were of little consequence until Ericsson invented the screw propeller in 1836.

In 1903 Orville and Wilbur Wright went to the sand dunes on the coast of North Carolina to experiment with flying. Curious villagers at Kitty Hawk gathered



Philip D. Gendreau, N. Y.

This news photographer's pictures will appear in next morning's papers on the other side of the world

around to talk. One of the group asked if they really expected to build a machine to fly. Mr. Wright picked up a cigar box lid and sailed it through the air. "That sails until the force is exhausted," he replied. "Yesterday you shot a hawk. That hawk sailed until you stopped its power. If we can find a source of power to fit the machine, it will fly." The Wright brothers found the power in the gasoline engine, learned the science of air pressure on wings, and made the first successful flight. Now machines fly the Pacific. Nothing wonderful, you see airplanes every day! But to think out the first one and make it work, was wonderful to the people who saw it fly.

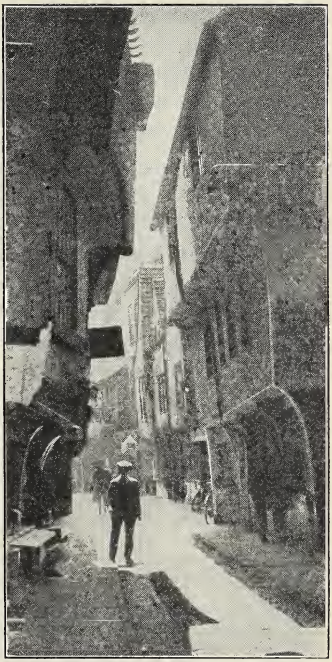
The first telegraph line was built from Baltimore to Washington in 1844. The first successful cable for telegraphing across the Atlantic was laid in 1866. Marconi sent the first wireless message across the ocean in 1901. Motion-picture theaters were opened in the United States in 1905. In the days of the American Revolution it took a sailing ship a year or more to bring news from China to Boston. Now we see and hear the news of the world while it happens.



Globe Photos, N. Y.
A rat guard on a ship's hawser. Science protects us from the great plague

Now let us go back, in imagination, to a century before Paul Revere's ride. Let us journey to London, the seat of the government of the growing British Empire, and the largest city of its time. The city is interesting and picturesque, but the streets are indescribably filthy, and the homes of the common people miserable. The streets are

used as sewers, and all kinds of refuse is thrown into them. Overhanging upper stories shut out the purifying sunlight and increase the danger of disease. The writings of the day tell us of the vile stench of this street or that one. For drinking water you find the people carrying buckets or pitchers to pumps situated here and there along the streets. There is no running water in the houses and there are no indoor toilets. The seepage from the garbage in the streets sinks into the ground and finds its way into the public wells. How would you like to use such water for drinking?



Philip D. Gendreau, N. Y.

A street in York, England, that has changed little, except in cleanliness, since the Middle Ages, but in those days there were no lights, no paving, and all refuse was thrown into the street

Conquering disease. If we make our imaginary visit to London in the year 1665, we shall find things more vile and terrible than usual. All persons who can do so, have fled from the city. It is the year of the terrible plague. We see, as we go about the almost deserted streets, red crosses marked on certain doors. They are quarantine signs; plague is within those houses. At night horse-drawn carts rattle through the dark streets, and the drivers' harsh voices call, "Bring out your dead." Terrified relatives bring

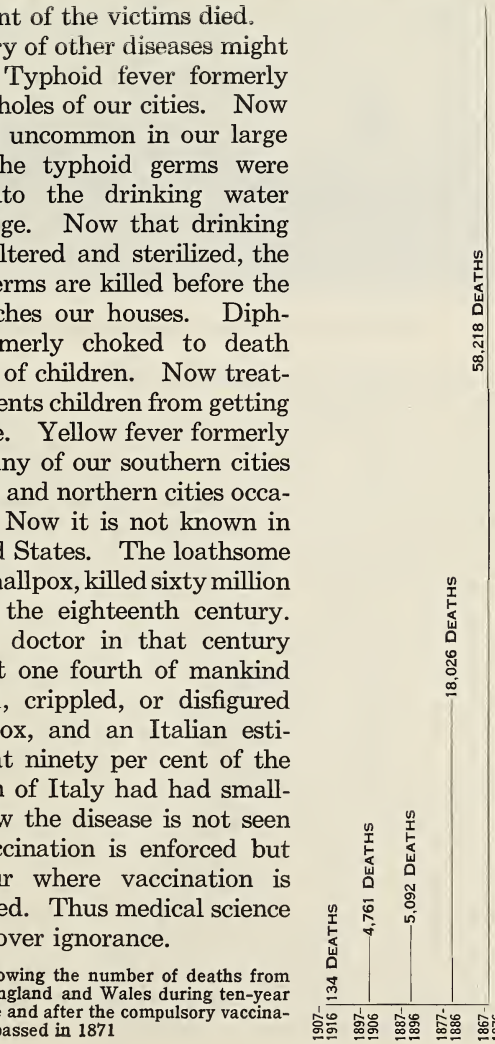
dead bodies from the houses and lay them in the street. By the flickering light of torches they are tossed into the cart with irons or pitchforks, and the wagon, piled with corpses, rumbles away in the darkness to the trench outside the city where the bodies are dumped like so much rubbish.

This great plague, which carried off 65,000 of London's 400,000 people, was only one of the many that have swept over the Old World since the days of ancient Greece and Rome. In 1630 the plague killed half a million people in the Republic of Venice, and destroyed the might of that once powerful state. Where the plagues came from, what caused them, how they were spread were mysteries to the people.

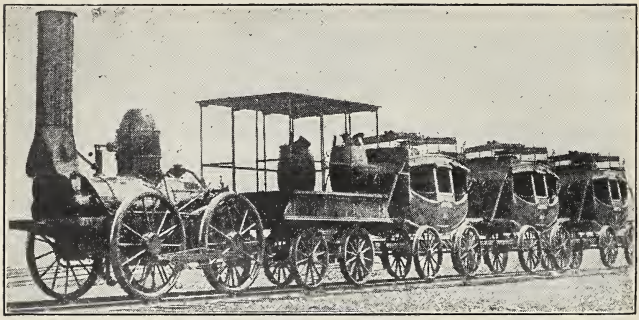
In later days science was to solve the mystery. We know now that the causes of plague are rats. On the rats live fleas. In the fleas may live the germs of plague. Scientists have seen the germs under the microscope. When the Great Plague swept over London in 1665, the microscope had been invented, but microscopes of those days were poor instruments and their use little understood. Disease germs were unknown. It was not until over two hundred years later that the germs of plague were seen under the microscope. The plague comes to us no more, but it may come, if scientific watchfulness is relaxed, if only for a few months. There are places in the world that are plague centers. Even in parts of our own country, plague has been found on ground squirrels as well as rats. We are safe so long as the guard of science is on duty—but only that long. In 1918 influenza swept around the world and many people died. But the fear it caused was not the blind panic of the old-time plague. Fear mobilized the health authorities and scientists to fight and conquer the disease. In the Great Plague sixty-five per cent of the victims

died; but in the influenza epidemic only one half of one per cent of the victims died.

The story of other diseases might be told. Typhoid fever formerly made pestholes of our cities. Now typhoid is uncommon in our large cities. The typhoid germs were carried into the drinking water from sewage. Now that drinking water is filtered and sterilized, the typhoid germs are killed before the water reaches our houses. Diphtheria formerly choked to death thousands of children. Now treatment prevents children from getting the disease. Yellow fever formerly visited many of our southern cities frequently and northern cities occasionally. Now it is not known in the United States. The loathsome disease, smallpox, killed sixty million people in the eighteenth century. A French doctor in that century wrote that one fourth of mankind was killed, crippled, or disfigured by smallpox, and an Italian estimated that ninety per cent of the population of Italy had had smallpox. Now the disease is not seen where vaccination is enforced but does occur where vaccination is not required. Thus medical science triumphs over ignorance.



A graph showing the number of deaths from smallpox in England and Wales during ten-year periods before and after the compulsory vaccination law was passed in 1871

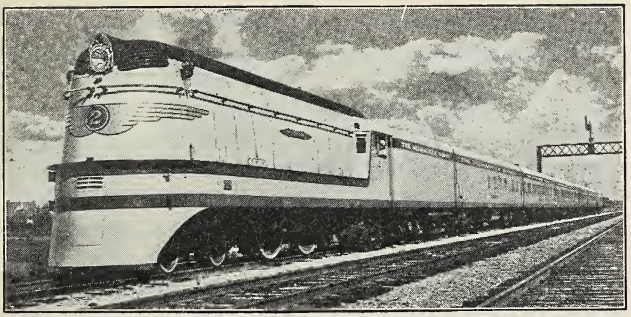


Keystone View Co., N. Y.

Perhaps this locomotive hauled your great-great-grandfather

Supplying the needs. Look back at London at the time of the Great Plague with its 400,000 people. Today it has over 4,400,000 and over 8,000,000 in the London area. Greater New York has over 6,000,000. Chicago has over 3,000,000. Philadelphia has over 1,900,000 and Los Angeles over 1,200,000. The present population of one of our great cities could not have lived in a city of 1665. They would have starved to death. If the railroads leading into New York were to stop transportation, in a day or two, people would be hungry. Try to imagine moving food and other supplies for 6,000,000 people into the city by horse as in 1665. Our great cities could not exist without the products of modern industry, the industry that science has produced.

Science has been a long, slow growth in knowledge of nature, the use of its materials, and the control of its forces. Turn back in imagination a hundred thousand years. There were no cities and probably no villages. Caves and hollow trees, or mere walls of grass and mud to shut out the wind and storm, served as homes. Clothing was skins stripped from animals killed by stones, clubs, or sticks sharpened by scraping



Kaufmann-Fabry, Chicago

But he would have enjoyed riding on this train much more

with sharp stones. The first force of nature brought under control was fire. It was thousands of years after the taming of fire that man learned to get metal from the earth and use it to make weapons and implements. The iron age began in Egypt and Asia about 1300 B.C. It was not until 1765 that James Watt, a Scotchman, invented his steam engine. In 1804 the first steam locomotive ran on rails. The first trolley car ran in Baltimore in 1885. Then the world began to speed up. Industry began to assume its modern organization. In the last fifty years man has made more progress in capturing the forces of nature than in the hundred thousand years before.

Feeding the world. The population of the world has trebled in the past 160 years, it has been estimated. The farmers of 1665 could not have fed the world of today. Farmers then sowed and reaped by hand implements. McCormick invented his horse-drawn reaping machine in 1834. Now the giant combines, drawn by tractors and driven by gasoline engines, reap and thresh the grain in one operation in the great wheat fields. Even if the early farmers could have grown such wheat crops they could not have moved

or stored them in 1665. In the days of old London the great wheat lands of Canada and the United States were the land of buffalo and Indians. The wheat lands of Argentine and Australia were unknown. Corn, the most valuable crop in the United States, was known as something the wild Indians and the American colonists grew. The meat supply of the world lacked its most important supplies from North and South America, Australia, and New Zealand. Without refrigeration and steam transportation, cattle and sheep in these lands would have done Europe little good, even if the supply had been there.

New varieties of wheat produced by scientific experiment have moved the wheat belt into the Canadian plains and the dry lands of the West. Science has produced a great host of other varieties of fruits, vegetables, and farm animals that have fitted the newly settled lands and climates of the earth. The half-starved world of the Middle Ages need not exist today. We now can produce more food than we can consume. But there are other problems to solve before the world is no longer hungry. Some of our greatest problems today are the problems of dealing with people. They often do not want to be dealt with scientifically. We are conquering the forces of nature.



Small methods meant small farms

We have not yet conquered the force of human greed that will allow men, women, and children to go hungry, poorly clothed, and poorly housed when there is abundance in our country. We need to study the methods of natural science that have been so successful in controlling the forces of nature and apply them to the control of humanity.

To Learn a Few Things That Science Has Done for Us

I. Investigate our progress in science since the early days of the United States.

1. From your studies in American history and your knowledge of what happens today, you perhaps can tell about a swift journey from Philadelphia to New York in the days of Washington, or to California in the days of '49. Then tell about the journey today.

2. The Battle of New Orleans was fought after the treaty of peace had been signed. Why was the battle fought? How long does it take the news of a speech of a European dictator to reach the United States today or the speech of the President of the United States to reach Europe?

3. Contrast keeping warm in winter in a city in colonial days and keeping warm in the same city today. Contrast feeding a city then and now.

4. Look in your history books to learn how wheat was planted, harvested, ground into flour, and baked into bread in colonial days. How was it taken to market? Look in books on geography, industry, and science to learn how these operations are performed today.

5. George Washington died following an attack of sore throat. You may be able to learn how he was treated for this condition. What is the treatment for the same condition today?

6. Your class may be interested in starting or continuing a manuscript library (accounts written by hand) by the pupils, of information of the kind suggested in the questions above that is not in your textbooks. Be careful to give the author, title, page, and date of copyright of the book. If the information is told to you, record who told it and the date.

II. Read the chapter.

III. Test yourself with the following questions:

1. List a series of inventions that have steadily improved communication. Can you tell the scientific principles involved in each of these discoveries? You will study them later in your courses in science, but it is interesting to see how much you know about them now.

2. List discoveries and inventions that are involved in feeding the people of a great modern city. Start with the soil and carry through to the final product as it is eaten.

3. If you live in a city, list in the form in which you meet them, all the things you meet in a day that are the products of science. You may give up before the day is over. If you live on a farm, try the same study. Do not forget what science has done with animals and plants.

4. Tell the cause of malaria, plague, and several other diseases. Tell how each is prevented.

IV. Think out or investigate the following:

1. What improvements in communication are now being studied by scientists and engineers?

2. What improvements in transportation are being studied?

3. What unconquered diseases are being studied?

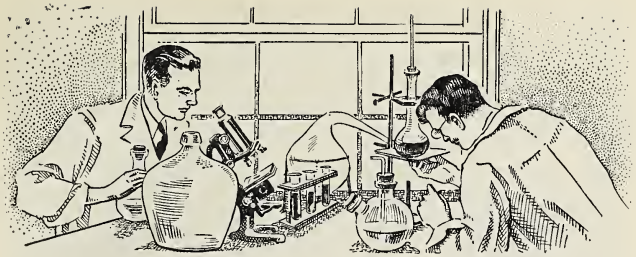
4. List all the diseases that we know how to suppress but do not suppress. Why do we not stop these diseases as we have the plague and yellow fever in this country?

V. A word list.

You must have words to name things and you must have words to tell what you think. As you study science you must have scientific words, and you must also have English words, common words, to tell your thoughts. You will meet new words as you read this book. To learn them, write them down in your notebook. In class, with the help of your teacher, you may discuss these words and see that you really understand them. Then you may draw up a class word list. You only can make up the list of words that *you* need. Watch for new words and write them in your notebook. Learn to spell them as soon as you meet them. That is very important. At the ends of chapters you will find some suggestions. You may know some of these words. Make sure. Then write down those that you really need. Here are some suggestions:

pest	loathsome	mahogany	vaccination*
refrigeration	plague	investigate	sterilize

* Watch spelling.



UNIT I

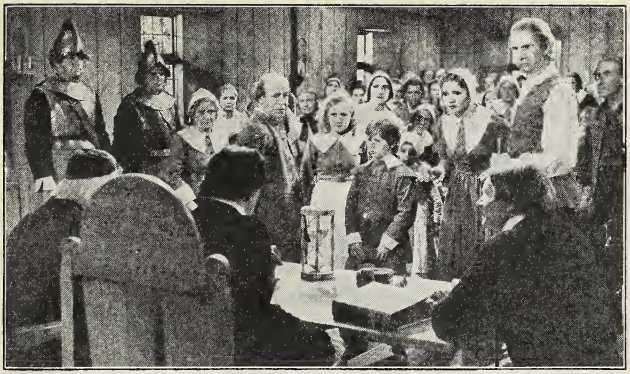
WHAT IS SCIENCE?

YOU ARE studying science, but just what is it that you are studying? What is in *science?* Perhaps you have seen the wonder stories in the Sunday supplements and have a vague idea that science deals with wonderful things. It is the study of wonder, of strange happenings, of strange animals, of strange places, of worlds far beyond our own, of distances so vast that our fastest airplanes could not travel them in a million years, of queer things that go on inside our own bodies, of terrible diseases and miraculous cures by white-coated doctors, of machines by which from your home in Bangor, Maine, or New Orleans you can some day watch kangaroos hopping about the back country of Australia.

One scientist said that science is common sense, arranged in orderly fashion. A scientist is always trying to reduce confusion to plain common sense. For that reason, he does not accept an explanation that "explains" by telling you something mysterious or supernatural. The explanation of nature must be natural. A faint white figure cannot be a ghost, because a scientist cannot catch a ghost and find what sort of animal it is. The faint white figure that glides away through the bushes along the marsh may be a mist or a white cow in the night. The wailing about the haunted house may be wind vibrating a wire or whistling through a crevice. Always the explanation must be in terms of things and forces that the scientist finds in nature.

In science you study nature, living nature and nonliving nature. Everything that is alive and everything that is not alive may be studied in science. There is nothing too small, even though it is too small to be seen with the most powerful microscopes. There is nothing too large, though it is a million times the size of the earth as, for instance, the sun or the big stars many times larger. There is nothing too far away, if there is any evidence that something is "there," as bodies in the sky much too far away to be seen by the most powerful telescope. There is nothing too near, as the human body and even the mind of man. Everything in nature and human nature is the subject of science.

It is not so much what a scientist studies as how he studies it that makes the study science. You know a scientist observes things. He must. His explanation must start with what he sees or hears or feels or otherwise observes. It is not easy to learn to observe. Ask your neighbor in class to tell from memory what color your teacher's eyes are. How many of your class have really observed? Students of science must be trained to observe. Then you know scientists experiment. Perhaps you think that is where the fun of science will come, in playing with test tubes and getting pretty colors or ringing bells or setting off explosions. What is a scientist "up to" when he experiments? What is an experiment? In this unit we shall get some kind of answer to the questions that have been raised, chiefly the question, "How does a scientist think and experiment?"



Paramount Pictures, Inc.

CHAPTER TWO

LEARNING WHAT CAUSED IT

Natural or supernatural. Did you ever hear the deathwatch? At the dead of night when you are lying awake, all alone up in the top story and all around everything is deathly still, you hear a "tick-tick-tick-tick." It seems to come from the wooden bed frame, or the baseboard along the bottom of the wall, or a door frame. If you know that it has been called the *deathwatch*, it may make you feel creepy. There is no doubt that you hear it: "Tick-tick-tick-tick." How do you explain it? If you inquire, someone may tell you that "it" is counting out the minutes of a dying person. If you ask, what is it that does the ticking, you may be told only "the deathwatch." It is something supernatural, ghostly. That makes a good story if you like ghost stories, but probably you have passed the ghost-story stage and demand an explanation by natural causes.

Scientists have found the mysterious "deathwatch." It is a kind of beetle that bores into wood. The ticking of the deathwatch is merely the beetle butting

his head against the wood to call his mate. We like the story, and call him the *deathwatch beetle.*

No mysteries can live in science. There are many things that we cannot explain yet, but the scientist has hope always that such things will be explained. The scientific explanation must always be natural causes, not supernatural.

Did you ever hear of a water witch? In many parts of the country when a farmer wants a well dug, he gets a water witch to tell where to dig to reach water. A forked hazel twig is cut and held in a certain manner. Then the person walks about here and there. According to the superstition, when the person passes above a favorable site for digging a well, the end of the switch will turn down.

To you, as a student of science, it sounds like an idle superstition. You can see no reason why the hazel switch would turn down over water. Yet many people today accept the findings of the water witch, and they may point to good wells dug at places a water witch had indicated. Do you see anything wrong with the reasoning? Suppose the farmer had dug somewhere else, what would he have found?

One time a group of teachers, some of whom were teachers of science, for amusement cut a hazel switch to try out its waterfinding power. As they walked about the yard one after another carrying the forked switch, the switch turned down usually about the same place, due probably to tiring muscles. One member of the party knew, but had not told, that near that place ran a water pipe. Does that show that the hazel switch told the truth?

If there are two possible explanations of an event, one a natural common sense cause and the other a mysterious power, which do you prefer? The scientist's explanation must make sense, not mystery.



Air vibrations set in motion by a shout will sometimes start a snowslide like the one which these guides are watching
Philip D. Gendreau, N. Y.

One evening at a dinner, a story of a modern miracle was related. A young woman who had no faith in modern miracles started to laugh loudly—and a large piece fell out of her empty tumbler. How could you explain that occurrence? Was that a supernatural rebuke for doubting the miracle? The superstitious might jump to that conclusion. If, however, you happen to be musical, you might remember that the great singer, Caruso, would hold up an empty glass and break it merely by singing. Instead of supernatural explanations, there is a very simple scientific one. When you speak, the vocal cords in the Adam's apple, or larynx, vibrate. You can feel the vibrations by holding the fingers on the Adam's apple as you speak. The vibrations of the vocal cords set the air vibrating. If the voice is of the right pitch and strength, the air vibrations may set the glass vibrating. If the vibrations are just right, they may break the brittle glass.

Before accepting a mysterious and supernatural force, let us see if a natural force will explain an occurrence. Much superstition remains today because people are not familiar with natural forces all about us. In your course in science you will study natural forces in the world about you.

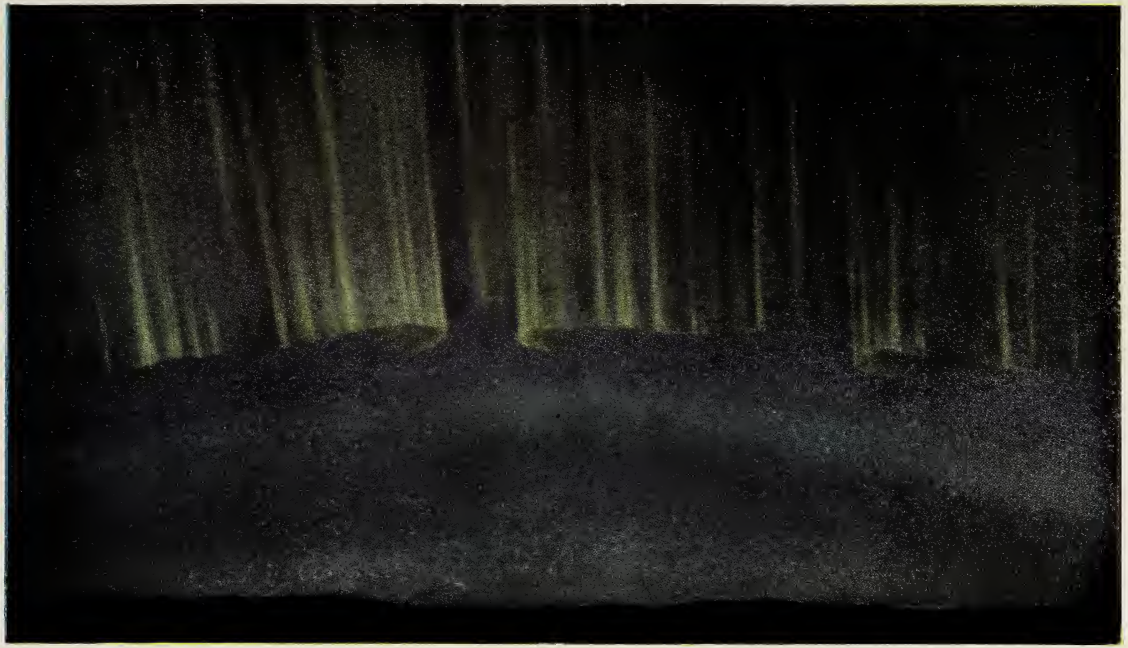
An ancient explanation and a modern one. Have you seen the Northern Lights, the Aurora? A good view of the Northern Lights is worth a thousand-mile journey, and if you have seen them and the glory of their colors, you will never forget them. Often you see them only as great, faint arcs or half circles, curves of light bending over the north, perhaps one above another. Or you see them as great, ghostly streamers that stretch from the north, spreading out on all sides like the rays of a great fan until they reach overhead. As you watch, they may change without your seeing when they changed, or they may shoot out rapidly and silently—and ghostly.

When they are at their best, there are great, colored arcs and sheets and streamers, red, green, lavender, yellow, and white. They change as you watch, sometimes like great silken curtains being drawn across the northern sky, silently, majestically. Or a great many-colored streamers follow one another in rapid and brilliant succession shooting upward to great heights, falling, spreading, vanishing, and appearing again in different variety of color and design—silently, wonderfully. Shall we say mysteriously?

What makes the Northern Lights? No one who has seen them can avoid wondering. The ancient peoples wondered, and their wise men offered them explanations. Here is the story told by the ancient Norsemen. In their far northern country, the Lights are brilliant and frequent. So striking a phenomenon (happening) in nature had to be explained.

Odin, the great king of the gods, living with his warriors in his great hall, Valhalla, knew, as all gods knew, that an evil day was coming when they would need to fight the forces of evil.

For that great battle of the good against the evil, Odin gathered his forces. After every battle on



Courtesy The Book of Popular Science, published by The Grolier Society, Inc.

The Aurora Borealis. In the glory of the northern lights the earth displays the electrical influence of the sun

earth, he sent his battle-maidens, the Valkyrie, to gather the souls of the brave and chosen warriors who had been slain and to bring them to Valhalla. As these swift maidens rode out, the light shining from their brilliant armor was the Northern Lights. Whether or not you believe it, it is a beautiful story.

Science does not find any evidence of battle-maidens riding out from Valhalla, but it finds some other equally interesting things about the aurora. Something flashes out, not from Valhalla but from the sun. For the aurora is brilliant when the great disturbances on the sun, the sunspots, are active. Then, also, we have magnetic storms on earth. Radio becomes indistinct and will not carry. The telegraph lines fail to work, and messages will not go through. The sun's rays coming to the earth upset the magnetism and electric phenomena on the earth. It is not in something supernatural, like mysterious battle-maidens, but in the common natural forces electricity and magnetism on the earth and in the air that science finds an explanation. Science can accept no explanation that gives only another mystery to explain what we want to know.

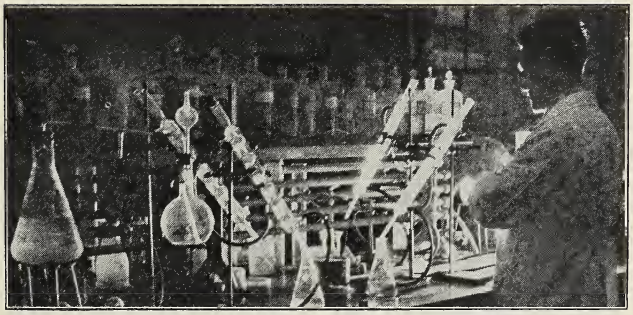
Scientific thought. Notice how the scientist thinks. Why does he think that the Northern Lights are electrical and magnetic phenomena? He has not measured their electricity as he measures the electric current in the laboratory or as the electric company's man measures it in our homes. He has not measured the magnetism of the Northern Lights. But he notices that the electromagnetic apparatus of the telegraphs and the radio go wrong when there are brilliant displays of the Northern Lights. He notices that these disturbances take place at the time of the sunspots. He has made measurements of the rays coming down from the sun, and he has learned much

about the rays at the time of sunspots. He knows much about the magnetism of the earth. He knows much about the actions of gases like the high air when electricity passes through them. None of these things tell him directly what the Northern Lights are, but they all tell him something. All the facts are evidence. They are like the evidence that is placed before a jury in a trial. From all the facts that can be found, the jury must come to a decision. So must the scientist. When he cannot get a direct answer to a question, he must consider all the facts he can find, and on such evidence come to a conclusion.

A scientist, however, must not use evidence as a lawyer does to prove that his side of the case is right and the other side wrong. The scientist is equally anxious to prove that he himself is wrong, if need be. The lawyer uses only the evidence that supports his side. The scientist must consider all the evidence against his idea as well as all the evidence for his idea. He wants to know all the evidence so that he may find the true explanation.

You have heard that a woman has a right to change her mind. So has the scientist. Indeed, the scientist must change his mind if new facts are found which do not agree with his former decision. New evidence may remake science. It often does. Our knowledge changes. Science must change.

Malaria, called *chills and fever* in many places, was called *malaria* from two Italian words, *mala aria, which* mean "bad air." It was noticed that people who were about at night in the low swampy lands got the chills and fever. If one stayed indoors at night and shut out the "bad air," one would not get the disease. We now know that if one lets the night air in the windows but shuts out the mosquitoes with screens, one will not get malaria. It is not the air that carries the



The Borden Company, N. Y.

A scientist asks Nature a question

germs of the disease, but the mosquitoes. The germs have been found in the body of the mosquito and in the blood of the sick person. The doctors had to change their minds.

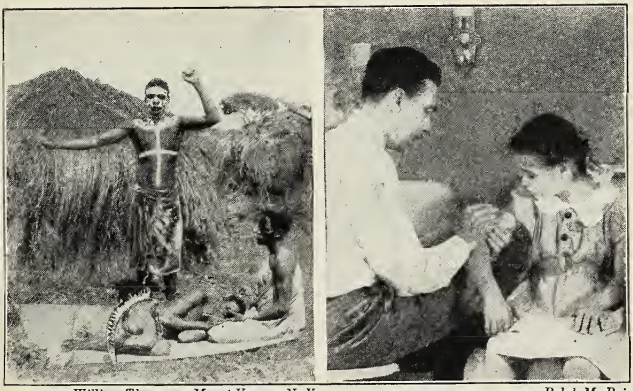
Willingness to change one's mind and desire to have one's findings proved true are marks of the true scientist. Such a man does not accept as final his own discovery or theory until it has been proved by other scientists of equal skill and ability. As in the celebrated story of Dr. Jekyll and Mr. Hyde a chance and unknown impurity in a drug produced an effect which the discoverer could never again obtain, so an undetected error in method or observation may produce an incorrect result in the scientist's work or conclusions. He knows that he has made a discovery, but he calls upon his fellow scientists to prove that he has done so. Other men, working in different laboratories all over the world, repeat his methods. If they all reach the same conclusion that he did, his findings are accepted as a scientific fact. Until they do, he has merely offered a theory that may or may not be correct. This is the true scientific method. The magician, the voodoo doctor, and the quack

shroud their "discoveries" in secrecy, mystery, and confusion—the scientist passes his on to the world.

Cause or coming first. A gentleman in a village in a certain progressive State, once took to his farm in the back country, a calf with a large growth or "wart" on its leg. The superstitious old farmer said he would cure that wart. He advanced to the calf, muttered some things which the gentleman could not understand, then made some passes with his hands in a peculiar way. "Now," he said, "the wart comes off." Later, on returning to the farm, the gentleman was taken out to see the calf. "There," said the old farmer, "wart gone." The farmer had done nothing further, but the wart surely was gone. The old farmer was convinced that the muttering and passing with the hands had brought about the cure of the wart.

A country doctor tells the following story of his practice: One day he was called to see a patient violently ill and with high fever. He knew of a certain serum which had been used in this disease. He secured some of the serum and injected it that night when the patient still had the fearfully high fever. The next morning the patient was very much better and made a speedy recovery. Did the serum cure the patient? A few years later, the doctor was called to see the same kind of case, again the patient had a very high fever. The doctor tried in all the neighboring towns to get the serum but was not able to get any. He went back to the patient next day and found the temperature had fallen, and the patient then made a speedy recovery without the serum and in exactly the same manner as the patient who had received the serum.

The doctor, after the second case, suspected, of course, that it was not the serum that had cured his first patient. The old farmer continued to believe



William Thompson, Mount Vernon, N. Y. *Ralph M. Bair*

The voodoo doctor pretends to cast out devils by magic; the modern physician fights germs, which are the "devils" that cause disease, by scientific means

that his magic had removed the wart on the calf's leg. The wart disappeared after the magic, but did it disappear because of the magic? Because one event precedes another, does it necessarily mean that the first caused the second?

In the United States erysipelas has been treated by carrying burning sticks around the sick person. The person sometimes recovers after the ceremony. Persons also recover from erysipelas when burning sticks have not been carried around. Much superstition has originated because the cause and the time of occurrence were confused. The car was wrecked after a black cat crossed the road. Did the black cat bring bad luck? Think of how many cars are wrecked when no black cat has crossed the road. The potatoes grew because they were planted in the dark of the moon. How many potatoes grow that are not planted in the dark of the moon? Just because one event happened before another, is it certain that the first event caused the second?



If the black cat caused this accident, it was due to the driver's superstitious fear of black cats

A summary of how a scientist thinks. A scientist hunts for the cause of events among natural forces, not among supernatural. Although the cause may not be found immediately in natural forces, the scientist has faith that it may be so found. In the meantime, he "suspends judgment."

A scientist demands accuracy in observation. He knows that he must be trained to observe accurately. He demands that his own observations be verified (proved true) by other scientists.

A scientist wants all the evidence, facts, that he can find. He does not neglect those which do not support his conclusions. He is ready to change his conclusions when they do not fit with newly discovered facts. His conclusions must fit all the facts.

A scientist is careful not to mistake one event for the cause of another merely because the first happens before the second.

Where it is possible to find the facts by experiment, the scientist does not just do things to see what will

happen, but plans the experiment carefully to learn a fact that will answer a definite question.

A scientist does not say that he knows the final truth. He knows that he may need to change his explanation when new facts are learned.

On Learning What Caused It

I. Read the chapter.

II. By observation and experiment investigate cause and effect.

1. Are there "mysteries" about your house? Lay plans to learn what causes them.

2. Make a list of "mysteries" that you would like to have explained. What kind of forces must explain these mysteries? See if you cannot run down the explanation to one or more of the mysteries.

3. Have you seen a "magician" give a performance? Can you explain any of his magic?

4. Get a book on magic and parlor tricks. Try some of them before your class. Have the class find the causes.

5. Try out some of the superstitions, like that of the water witch, and report to the class. Here are some more: It is bad luck to walk under a ladder; to raise an umbrella in the house; to break a mirror. Your class might make a list of superstitions.

6. Explain some modern miracles by natural causes.

7. The ancient Norsemen explained thunder and lightning as the hammer of the god Thor hurtling at an enemy. How do you explain them?

8. Collect all the evidence that you can which will help you to answer a question like one of the following: Why are thunderstorms more frequent in summer than in winter? Do dogs think? Could people live on the moon? After you have listed the evidence, reach a decision. Then make sure that you have considered all evidence against as well as for your decision. If you find more evidence later, go back over all the evidence to see if you want to change your decision.

9. Do swallows bring the summer? Does an east wind (or a west wind or a south wind) bring rain? Does the finding of a four-leaf clover bring good luck? What mistake in reasoning is indicated by certain of these questions?

10. Go over the summary of how a scientist thinks and see if you think that way in and out of school.

III. Test yourself with the following questions:

1. What kind of forces must be used to explain questions in science?

2. How can you tell a superstition when you hear it?

3. How can you often show that a superstition does not explain?

4. If a scientist cannot get the direct answer to a question by experiment and observation, what is his general plan of study?

5. In using evidence how does the scientist differ from the lawyer for the defense?

6. Is a scientific explanation ever wrong?

7. Write down a list of the guiding principles of scientific thought.

IV. Think these out:

1. Does a politician use the guiding principles of scientific thought?

2. How would you examine these statements scientifically: High prices aid the farmer. High wages bring prosperity. All good science students make good marks.

3. Will a 20-pound ball fall faster or slower than a one-pound ball? Use your principles of scientific thought.

4. Is it possible to predict future events? Be scientific. The question is tricky.

V. Word list. You need words to express ideas. Build up your vocabulary (stock of words). Make out your own word list. Keep a pencil and your notebook beside you as you read. Write down the new words or the words that you want to remember.

vibration	phenomena	supernatural
evidence	larynx	vocabulary



World Letters, Inc.

CHAPTER THREE

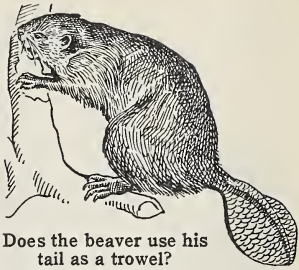
HOW TO ASK QUESTIONS IN SCIENCE

Stories you may have heard. Did you ever hear these stories? A hoop snake takes its tail in its mouth and rolls downhill like a hoop. Devil's darning needles sew up your mouth. The ground hog comes out of his burrow early in February, and if he sees his shadow, goes back to sleep, for there will be six more weeks of winter. The porcupine shoots its quills at you. In Madagascar there is a tree that eats men. You do not bother questioning those stories. They are just a little too tall.

Here is another set of stories: The beavers use their broad, flat tails as trowels to plaster the mud on their houses and dams. If one elephant is wounded, other elephants of the herd will come to its assistance and help it get away to safety. Garter snakes with young will open their mouths when danger threatens, and the young will crawl inside for safety. Squirrels migrate in droves. Some of these stories seem a little surprising and others may sound quite reasonable.



Does the porcupine shoot his quills at you?



Does the beaver use his tail as a trowel?

How to learn the truth. You might be interested to learn whether these stories are true. How could you find out? You might ask someone. You might look in books. You might go see for yourself. Each of these three solutions has difficulties. Whom shall you ask? What books or papers shall you believe? The appearance in print does not show that a statement is true. If you go to see for yourself, you may need patience at least. If you watched beavers long enough, you could no doubt come to a conclusion about the use of the tail. You might observe the behavior of garter snakes, particularly if you kept a number as pets. You might need to wait a long time to see squirrels in migration. With the protection of elephants in Africa, you may never have the chance to observe them helping a wounded companion. If you want to be sure about such questions as these, you would probably choose to see for yourself, but that is often impossible.

Whom shall you trust to see for you? When you read a book, you want to know whether the author knows what he is talking about. Is he a good authority? Is one man's word as good as another's? You would not trust a plumber's opinion about the sounds of your heart or a doctor's opinion about the way to join pipes. You want to know that the person who

makes the report has had a chance to observe and knows how to observe. Perhaps you think that anyone could make an accurate observation of a wounded elephant and its companions, or about beaver using its tail. But do not be too sure about that.

Can you observe accurately? Have you seen English sparrows? What color are they? How does the color of the male differ from that of the female? You perhaps have seen them many times, but unless you are very different from most people, you cannot answer those questions accurately. Now look at the birds. The female is the duller colored bird. If you do not have English sparrows around your way, tell about some common bird. Does a robin walk or hop? How many legs has a spider? When is the sun directly overhead? You need to observe accurately in science; have you learned to do so?

What is an experiment? "Don't kill that ant or it will rain!" a small boy called to another. Do you believe that killing an ant will cause rain? You might say that you could easily find out by experiment. Could you? How would you go about the experiment? You might kill an ant and see if it would rain. No doubt it would rain—sometime. Would that prove that the killing caused the rain? You do not hesitate to say that the killing experiment would prove nothing at all. The conditions of the experiment are not sufficiently under control. It would not be a satisfactory experiment. Of course you might set a time limit and say that the rain must come within twenty-four hours and then repeat the experiment many times under varying conditions of weather. But the question probably seems to you hardly worth the experiment. You must select the question that you can answer by experiment. You can think of many questions that cannot be answered by experiment.



Red sumac berries

Will you live again after you die? That question is not subject to experiment.

Now consider another series of questions. Are red sumac berries poisonous? Do birds return to the same back yards year after year? Do horsehairs turn into snakes? Will a certain preparation prevent chapping of the hands? Does a turkey buzzard see or smell a dead animal?

There is a way to find the answer to these questions. Try experiments, and observe the results. But now you meet difficulties. What sort of an experiment will you try to learn if red sumac berries are poisonous? Certainly you will not eat them to find out, and you cannot feed them to your neighbor's cat. A small farmer boy once said that he knew that horsehairs turned into snakes because he had tried it. He put a horsehair in a water trough and later he found a horsehair snake there. Did that prove that the horsehair turned into a horsehair snake? You have a feeling that there was something wrong about the farmer boy's experiment. It was not under control. To give an answer that cannot be doubted an experiment must be planned with care.

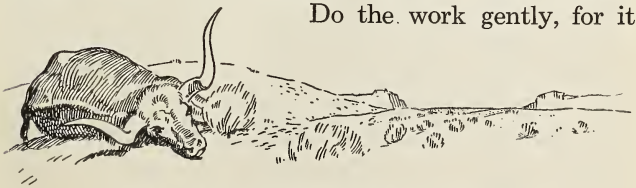
You must have clearly in mind what you are trying to find out by your experiment. What is the question that you are trying to answer? You are not just trying to see if anything will happen. That may be very dangerous in the laboratory. Write down the question that you seek to answer by the experiment or by any experiment that you can perform in your laboratory. You may find that you do not know what



you want to know. You must first get the question into words.

To see what an experiment should be, let us choose a question that is subject to experiment. EXPERIMENT No. 1. Does a ship sink to the same depth in fresh as in salt water? That is a clear statement of the question. We should be able to answer that *yes* or *no* by an experiment. Now let us select the materials and the method of carrying out the experiment. We cannot bring a ship into the laboratory.

Can we get something else that will answer the purpose? For this experiment the main thing about the ship that we wish to investigate is its floating. We might choose some other floating body, say a hollow rubber ball or a small flask with a cork or a block of wood. We shall need, in addition, a vessel or two to hold water, and some salt. Those are the materials of our experiment. Now what is our method of investigation? We might fill the vessels to a convenient height with water. Then into one pour salt, stirring the water constantly until it will dissolve no more salt and some falls to the bottom of the vessel. Now take the block of wood and very, very gently lower it flat side down into the vessel of salt water. With a ruler, measure the height of the top of the block above the surface of the salt water. Do the work gently, for it



Does a turkey buzzard see or smell a dead animal?

requires patience. Write down the figure. Remove the block then and immediately wash it off under the faucet. Dry it with a towel to have it again in its original condition, as far as possible. Then gently lower it into the vessel of water without salt. Measure the height of the top of the block above the surface of the water. Write down this figure. There may be very little difference with a block of wood, but remember $\frac{1}{16}$ inch with a block of wood may mean a big difference with an ocean liner. We might try the hollow rubber ball and the small flask also.

We can now tell whether the block sinks to the same depth in fresh as in salt water. Now we draw a conclusion, or make a decision, about the question we set out to investigate.

The report of the experiment. To complete the experiment we must write a report. In order to examine a report quickly and learn definitely what was found out by the experiment, it is necessary to have a clear form of report. The following form may be used in this course in science.

Question. Under this head write down just what question you are attempting to answer in the experiment. In the experiment just described the question is: Does a block of wood sink to the same depth in fresh and in salt water?

Materials. List all the materials that must be assembled to perform the experiment.

Procedure. Tell just what must be done to get an answer. Often a diagram of apparatus must be drawn.

Observation. Tell just what you saw when you performed the experiment. Very often measurements will be recorded under this heading.

Conclusion. Write the answer to the question you started with. (Tell the answer you reach to the question of the experiment.)

Application. Under this heading you may draw further conclusion than the immediate answer to the question of the experiment. For example, we wanted to know whether a ship would sink to the same level in salt and in fresh water. We could not experiment with a ship, so we used a block of wood. After measuring the block and looking at the results, we could draw certain conclusions about the block of wood. It sank to the same level or it did not. Then we could apply this in our thinking about the ship and answer the question, Does a ship sink to the same depth in salt as in fresh water?

Now perform the experiment with the block of wood in fresh and in salt water and write up a report.

To Learn How to Ask Questions in Science

I. Read the chapter.

II. Look up facts.

1. On separate slips of paper write down all the superstitions, stories, and statements that you think are worth studying. Classify them by sorting the slips into piles. (1) Plain superstitions, like the ground hog seeing his shadow. (2) Stories that you would immediately dismiss as untrue, like the man-eating tree. (3) Stories that you might think to be true, but which you could not prove true by your own observation. (4) Stories that you could prove true or false by experiment or observation.

2. Go into the library with No. 3 pile of slips. Look over the shelves and look through the catalog for books that might give you information. If you have a large pile you cannot look up all. Select a small number, perhaps only one or two. Locate the book and examine it. Who is the author? Is he an authority on the subject? What can you learn from the title page and the preface about the author and the book? Then look up the story. Can the author answer from his own observation or does he speak

on the authority of another? Has this second person observed? Does the observation seem sufficiently accurate?

3. Perform the experiment outlined in the chapter and write up the report if you have not done so.

4. Now go through the No. 4 pile of slips. Select one that you may answer by experiment. Make sure that you can carry out the experiment with your facilities. Plan the experiment as outlined in the chapter. Write a report.

5. Plan and carry out an experiment to answer the following question: Does boiling water get hotter when you turn the gas flame higher?

III. Test yourself with the following questions:

1. How would you try to satisfy yourself that a story is true?

2. If you cannot observe for yourself, what should you know before accepting the account of another person?

3. What six steps are recommended in carrying out an experiment?

IV. Think out the following questions or find out by investigation.

1. Does salt water boil at the same temperature as fresh water?

2. At what time does the sun set the last day of this month?

3. The ancients said that the sun came out of the sea. Modern scientists say that mountains have come out of the sea. How would you learn the truth about the two statements?

4. Before investigating you may want to make an estimate of the probability of a statement being true. Judging probability requires thought. Here is a simple case: An inch is 2.5 centimeters. Are 25 centimeters more or less than 25 inches?

5. Is it probable that man will some day be able to fly by wings which he straps to his body? Be careful to see what the question means and learn what has been accomplished by gliders.

V. Word list. Are there any new words to add to your list?



UNIT II

WHAT IS AROUND US?

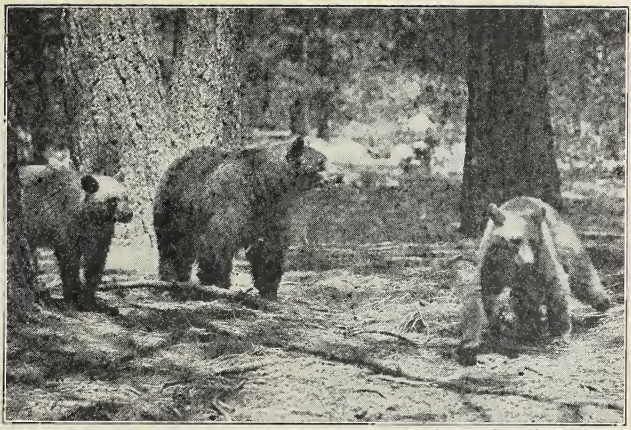
YOU LIVE in the midst of things. You cannot live alone. You are in the midst of city or village life, the life of the farm or the seashore, the life of the mines or the cattle ranch. It may be possible that you spend long hours with no other person near. Boys twelve years old herd sheep and cows all day long, perhaps with a dog. Others sometimes spend long days working in the woods or along the shore. But are they quite alone with no living thing near?

There are living things a-plenty in the woods, on the ranges, and the shores. You may need to look for them, and then find them looking at you all the while, like the red squirrel on the branch. There are others beneath your feet, some without eyes like the earthworms, living a part or all of their lives safely buried in the soil. There are little things in the grass and the soil and in the waters—insects, fishes, crabs and their cousins, like the crayfish. There are many things so tiny that they can be seen only with the microscope. There are plants living about you, even in the city. Some of the plants are tiny, microscopic. Many of these tiny plants you would rather not have near you, for they are germs of disease. But the tiny germs of disease make a living on the earth whether you like it or not. Disease germs were here before you were and others will be here after you. They are part of the living things of earth. You must live among them if you live.

All the living things on earth have found some sort of place in which to live. Some places are dry and dusty; some are under water; some are inside other living things. Always there is something around. They do not live in emptiness. They live in the sort of surroundings in which they can make their livings. The sea gull does not live in the deep woods. The squirrel does not live on the rocky island far at sea. The fish and clam do not live in the grassy field. There is a fitness to things. Living things fit into their surroundings. Indeed they often fit in so well that you have a hard time finding them. The hunter may leave without finding the rabbits that he knows are in the field. The fisherman may not get a glimpse of the trout that he knows are in the pool. The animal and the plant must fit into its surroundings or it cannot live.

Do living things change their surroundings? Have you yourself made any change in your surroundings—in your bedroom, study room, school, camp, or picnic grounds? Do animals make changes in their surroundings and do plants? If they make changes, do they benefit or suffer by the changes? Does man always benefit by the changes he makes? Do you improve the picnic grounds by the changes you make? Do you intend to improve the surroundings? Do the animals?

We shall study in this unit the surroundings of animals and plants, how they fit into their surroundings, some changes they make. We shall try to answer some of the questions raised. If your mind is alive as you study this unit in the book and in the field and library, you will have many more questions to ask. You may find the answers to some of them in this unit. You may find answers to more in the fields and woods and the city. Some may be left unanswered. It is always so in science.



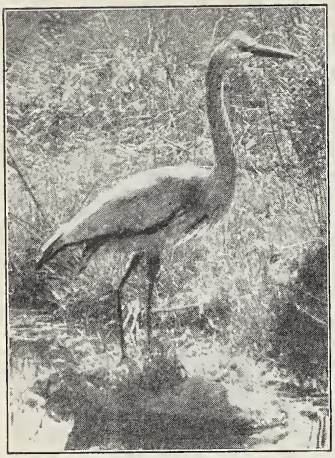
De Cou from Ewing Galloway, N. Y.

CHAPTER FOUR

THE SURROUNDINGS OF LIVING THINGS

When the Indian inside you has had a chance to grow as you roam the woods and the stream banks, the shore and the meadow, you learn in what sorts of places to look for certain kinds of animals and plants. In the deep shady woods you find the hermit thrush and the wood warblers, or if you have visited the wilder parts, perhaps you have seen signs of bobcat and bear. In deep or open woods you find deer. Near the edge of the big woods and in the thickets, you find great numbers of birds and animals, abundant squirrels and chipmunks, skunks and foxes, opossums and raccoons. Wood thrushes, tanagers, chickadees, kinglets, and many other birds abound, for the edge of the woods and the more open parts seem to satisfy and shelter greater numbers of living things than either the deep woods or the open fields.

In the open grassy fields you have learned to find the woodchuck, field sparrows and grasshopper sparrows, pheasants, and quail. If there are bushes and





1 Philip D. Gendreau, N. Y. 2 Ewing Galloway, N. Y.
Tell how the heron and the ground hog are suited to their surroundings

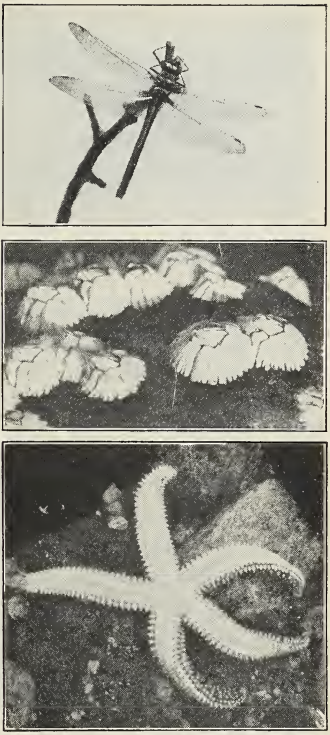
thickets near by, the population of birds and animals is greater. If briar tangles and brush heaps are at one side, you look for more rabbits. If wild flowers bloom, you look for abundant bees. Grasshoppers fiddle their tunes and crickets chirp about the ground. Among the tall weeds and bushes along the edge of the field, spiders spread their webs where the breezes blow the insects.

Along the pond shores and stream banks you may go to look for a different set of birds and animals. The little sandpipers run along water edge with their queer little tilting and bowing. Herons stalk quietly erect, or stand like statues, now and then shooting their long beaks at fish or frog. Wild ducks may feed among the reeds, and perhaps gulls may alight for a swim or a bite of food.

In the water are another set of creatures. Fishes, turtles, frogs and salamanders, crayfish and mussels are resting, hunting food, or escaping enemies. Whirligig beetles are circling around. Diving beetles are going below, crawling about the bottom and rising again for a fresh supply of air. On the dead sticks

at the bottom, young dragonflies are searching for smaller crawling things which constitute their food. Young May flies also are there, feeding and being fed upon. Young stone flies and caddis flies and midges are clinging to the stones. And there are hosts of other creatures. You can see them, if you search.

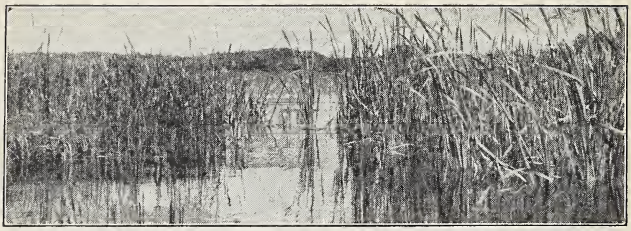
In the salt waters, how different are the creatures. Many more—mussels, clams, oysters, periwinkles, and crabs—are settled for life in one place or crawling about. The beaches of white sand have a population different from the rocks slippery with seaweeds or rough with barnacles. The sandy shore may look like a desert with only now and then a shore crab or other little crablike creature burrowing into the sand as the waves run back to the sea. On the rocks or piles of wharves are very different creatures, barnacles, sea squirts, starfishes, and sea anemones.



Hugh Spencer, Chester, Conn.

Tell how the dragonfly, the barnacle, and the starfish are suited to their surroundings

On the muddy salt-water shores are other creatures. Fiddler crabs come out of their burrows at low tide. Hermit crabs drag their borrowed shells about in the



H. Armstrong Roberts, Phila.

A rich growth of cattails in the water environment

shallow water. Worms live in burrows, and clams are safely settled within the mud.

As the tide comes and goes, the life changes on these salt-water shores. At low tides many creatures have withdrawn into their burrows. Sea anemones and barnacles have folded themselves together. Crabs have retreated with the falling water or have hidden away in the tangled seaweeds. Then gulls, crows, and shore birds, and perhaps stray cats or rats, come to search for food, dead or alive. And when the tide turns and comes in again, the population changes. Fishes and crabs come in from deeper water to feed. The barnacles and mussels upon their rocks and piles again open their shells to take in food and fresh salt water.

Plants, too, have each kind a place to live. As you cross a meadow you can tell the marshy spot from a distance. The dry hills are clothed with trees and grasses different from those of the rich lowlands. Once a scientist took a friend to find a *serpentine barrens*, barren land due to serpentine rocks, that neither had seen, although they knew the general region where it lay. As they crossed hill after hill and valley after valley, the scientist looked on ahead. Finally, as they came up the side of a hill, he called that it was just ahead. A mile away, he recognized



H. Armstrong Roberts, Phila.

A sparse growth of coarse beach grass in the sand

the blackjack oaks and red grass that mark the soil of the barren serpentine rocks. The sandy soil and the boggy soil has each its own kind of plants, as you can see in the pictures above and on the page opposite. The desert and the wet land have very different plants.

You know that different plants and animals need different kinds of surroundings. Woodchucks live where they can dig their burrows. Foxes live where rocks or dense thickets furnish dens or where they may dig dens not easily invaded. An eagle or a large hawk chooses a bare rock ledge or a high bare tree from which it sees approaching enemies from afar. The little field sparrow may fly up from its nest in the dense grass just at your feet. Muskrat and beaver find food and safety in streams and ponds. The tiger lurks "where the high grass hides the horseman." The polar bear stalks the seal on the Arctic ice. Even man fits into his surroundings.

Environment. Let us now use a new word, one that you probably have heard before and will meet many times in science and other studies as well as in newspapers and magazines. This word is *environment.* The surroundings considered together are called the *environment.* There are many different environments on the earth. The polar bear and seal



Philip D. Gendreau, N. Y. *Douglas from Gendreau, N. Y.*

In what ways would you expect these environments to affect the people who live in them?

live in one environment, the lion and zebra in another. You have seen different environments in your hikes, the woods, the dry fields, the marsh, the deep water. You have seen the environments also of different people, the city, the village, the farm.

Each environment is made up of a number of different things. The environment on page 42 is made up of mud, water, air, sunshine, and other parts. We speak of these parts as the *factors of environment*, for factors are parts that make up wholes. In addition to the factors of the environment just mentioned, a frog living in the environment shown on page 42 has also living factors in his environment. There are plants submerged in the water and plants ashore. There are insects and worms on which he feeds. There are herons and perhaps fishes which eat frogs. The desert animal you see on page 50 has some different factors making up his environment. So, too, a city boy and a country boy have different factors in their environments.

Though the underwater environment, the desert environment, the tropic jungle, and the icy Arctic shore are very different in many ways, there are certain factors that occur in all. These are the factors necessary for life. If there are living things present there must be air or at least oxygen, water, food or something to make it from, a certain amount of warmth, a support on or in which to live. If any of these factors are missing there can be no life.

How to Learn about the Surroundings of Living Things

I. Read the chapter.

II. By observation and experiment study environment.

1. In the fields and woods find different types of environment. Write up a report on each environment. In the report tell: the kind of environment, the plants and animals you find there, the factors which make up the environment. When you have drawn up reports on a number of different kinds of environment, list the factors which are found common to all these environments. If you have a camera, take pictures to illustrate your report.

2. List the factors of your home environment and of your school environment, then of your total environment throughout the year.

3. Visit different parts of your city and describe the different kinds of environment in which different people live in your city.

4. Write a list of plants and animals that share the environment with you.

5. If you can visit a museum in which are shown plants and animals in their natural environments, make reports of their environments you have not seen in the field.

6. In your notebook, paste pictures from magazines and newspapers illustrating different types of environment.

7. Set up in your schoolroom environments in which the following can live healthily: goldfish, frogs, grasshoppers, snails, bumblebees, and such other animals as

are easily obtained. Study first their natural environments and make sure that you can keep the animals alive before you capture them.

8. Create environments in your schoolroom for the growth of ferns and narcissus bulbs.

III. Test yourself with the following questions:

1. What is the term for the surroundings in which a plant or animal lives?

2. What is the name for the various parts that make up the surroundings?

3. Name several different types of environments.

4. What factors of environment vary in the pictures on pages 42 and 43?

5. What factors are common to these and all other environments of plants and animals?

IV. Think out answers to these questions, or make further investigations to learn the answers.

1. What factors in the environment are not so favorable for the development of children in the city as in the country? What factors are more favorable in the city?

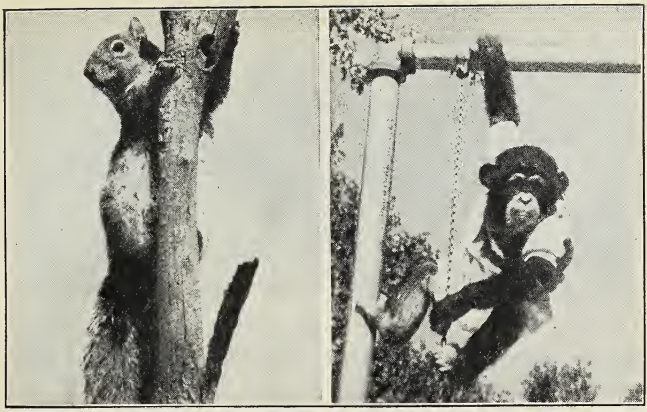
2. Are the factors of the city environment more favorable for men or for trees? for people or for pets?

3. On a Friday afternoon two boys brought to school four frogs for study. The frogs were placed in a tall jar without water and without a cover, and the jar placed on a sunny window sill. On Monday morning the frogs were found dead, shriveled, and dried. What factors necessary for life had not been supplied?

4. The Indians of what is now the United States at the coming of the white man had no beast of burden except the dog. Natives of Europe and Asia had all the beasts of burden we now have. Can you account for the difference by the factors of environment?

5. What factors of environment make the people of Pennsylvania primarily industrialists and those of Iowa chiefly farmers?

V. Your word list. Here are some suggestions:
environment factors factors of environment



Hugh Spencer, Chester, Conn. *Sally Pepper, Phila.*

CHAPTER FIVE

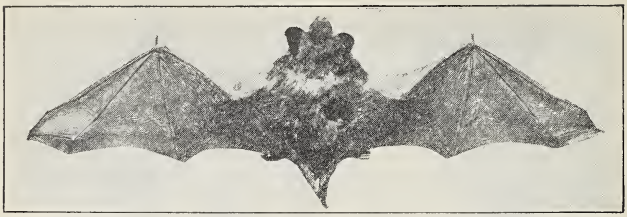
FITTING INTO THE SURROUNDINGS

Did you ever see a dog chase a squirrel up a tree and try to run up the tree after him? Why can the squirrel run up the tree, but the dog cannot? Look at the squirrel's paws and the dog's. Then see how the squirrel reaches out to each side and holds the rough bark. The dog tries to run up the trunk with his feet straight under him as he runs on the ground. It is little wonder that he fails. Have you watched a squirrel run out on a branch, sail through the air, and land on the tree across the road? That bushy tail balances his flight like the tail of an airplane.

Have you seen a monkey climb? Look at the chimpanzee above. A monkey climbs differently than a squirrel. The monkey's forepaw is not built like a squirrel's. The monkey grasps with one hand while a squirrel needs two. Having grasped a branch, a



1. A dog's paw;
2. a monkey's hand;
3. a squirrel's paw.



Hugh Spencer, Chester, Conn.

The bat's fingers and arms are adapted to flying. How?

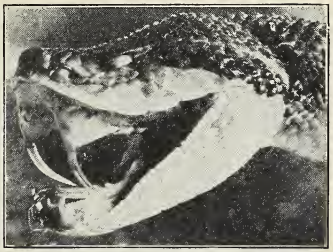
monkey can swing itself along like an acrobat on the flying trapeze. A monkey's shoulder allows freer arm motion than a squirrel's.

Two scientific words. Dogs or wolves are fitted, or adapted, to run down their prey (animals they kill for food) on the ground. A squirrel is adapted to run up a tree trunk and reach the nuts that grow on the outer branches. A monkey is adapted for swinging among the branches and grasping the dangling fruit. Learn that word *adapted.* It is much used in the science of plants and animals. *Adapted* means "fitted for a certain work in life." Thus we say that a monkey's free shoulder and its long fingers are adapted to swinging among the branches of a tree.

The scientists also have a word for the fitness of structures. Such fitness is called *adaptation.* The turtle's shell is an adaptation for protection. The rattlesnake's poison fangs are adaptations for defense. What are the dog's adaptations for defense? The bat's wing is a broad band of skin, an adaptation for flying. The grasshopper's large hind legs are adaptations for jumping and its wings for flying. A kangaroo's hind legs are adaptations for hopping.

Fitting its habits to its needs. An animal's habits are also adaptations. Dogs hunt about a field for animals that will serve for food. Crickets hide under sticks and stones and chirp their love songs

about the grass roots where their mates are creeping. Butterflies flit about the blossoms which provide the sweet juice that is their only food. Minnows dart about the shallows where they are fairly safe from the big fish that lurk in the deep, dark pools. Snakes lie out on the hot, sunny rocks but crawl into the rocky crevices before the chill of evening, for they can endure heat but not cold. Frogs live close to water or in damp places, keeping away from dry, hot roads until the dampness of night comes down. Then you may see them jumping across the roads. Many other creatures travel under cover of night. Can you think why?



William Thompson, Mount Vernon, N. Y.

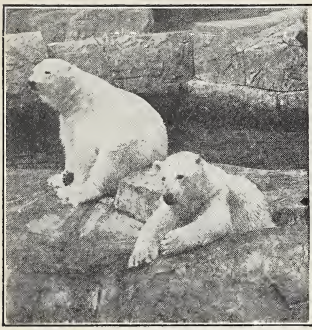
For what are snake's fangs adapted?

Adaptation or death. Adaptation is necessary for life. A creature that is not adapted to breathe under water cannot live there, and a creature that is not adapted to breathe free air cannot live in the open air. A cow is well adapted to feed in a grassy meadow but not in a butcher shop. A dog could live in a grassy meadow only if there were abundant rabbits, rats, mice, birds, or other animals to serve as food. A creature must be adapted to live on the food and air supply that its surroundings provide or it must move elsewhere.

All living things show adaptations to their environment. A polar bear's thick coat and his layers of fat keep him comfortable in the Arctic winter. The fish's streamlined body is adapted



Strong legs and wings are the grasshopper's adaptation for escape





Philip D. Gendreau, N. Y. *H. Armstrong Roberts, Phila.*

Tell how each of these animals is suited to its environment. Why could neither live in the other's home?

to glide through the water. The otter's webbed foot, like the duck's, is an adaptation to water environment. The camel's broad feet are adaptations that enable it to walk on the loose sands. Its hump is a store of food that keeps it alive during days of starvation. In its stomach are water cells which store water. All these structures are adaptations of the camel's body for its desert home.

Internal organs also are adapted to their work. The fish's gills are adaptations to water life, and lungs are totally unsuited for breathing under water. When a pearl diver goes below, he can stay at most about forty-five seconds. When the diver clad in modern diver's suit goes below, air must be pumped down to him to breathe and to fill his suit against the weight of the water. A dog or a bird must have much better lungs than the sluggish frog. They must keep up a good supply of air for an active life.

Does your body show adaptations? Compare your foot with the dog's. Which is better adapted to hold the body erect? How does a dog carry a stick? Examine your hand. Why can you hold an object in one hand while a squirrel needs two? Compare your

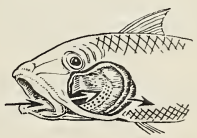


A dog's skull and a man's skull. Which teeth and jaws can bite more dangerously? Why does a man not carry things in his mouth as a dog does?

jaw with a dog's. Which is better adapted for fighting, catching a rabbit, or dragging down a deer as wolves do? How are you adapted for defense or attack? How is your arm better adapted for throwing a ball, swinging a tennis racket, or carrying a baby?

Adaptations of plants. The common plants of moist climates are not adapted to live in the desert. Cactus plants have hard, thick skins, adaptations to withstand the scorching desert sun. Their thick stems store water that lasts through the long rainless months. Other desert plants send out their leaves only when the rare desert rain comes, and the leaves fall away soon after the rains are over. Some desert plants store water in underground swollen stems.

Plants of the sand dunes along the sea and lake shores often endure desert conditions, for the loose sand does not hold water as better soils do. Many have thick, fleshy leaves, adaptations for storing water. Many, like the coarse beach grass, have crisp, hard leaves which roll together reducing the evaporation of the water from the surfaces.



The threadlike fringes of a fish's gills absorb oxygen from the water as it flows over them

You can recognize the delicate leaves of ferns and certain mosses as those of plants that love deep shade and moist places. The leaves of plants of the open fields are coarser and

harder or are narrow and divided. Twining stems and curling tendrils are adaptations that enable thin-stemmed plants to reach the sun by climbing on their neighbors.

The leaf stalks of water lilies enable the leaves to float on top of the pond while their roots are six or eight feet below in the mud. Thick stems in the mud store food which starts the growth the following spring. Many woodland and garden plants, also, that bloom in the early spring have bulbs and thick underground stems stored with food, adaptations that serve to give the flowers an early start.

To Learn How Plants and Animals Are Fitted to Their Surroundings

I. Read the chapter.

II. Look about you and see adaptations.

1. If you have a pet, study its adaptation. In what sort of environment did its wild ancestors live? What was their food? How is your pet adapted to get and use such food? What were the enemies? How is the animal adapted to fight or flee such enemies? Where did the ancestors make homes to care for their young or escape enemies and rest? What were they adapted to do in winter?

How is your pet adapted to live its present life? Is it adapted to live in your community if you give it no further care?

2. Study wild animals that live about and in your home, whether in city or country. How are they adapted to live in their environment? How are they adapted to survive winter or drought? Include insects in your study.

3. Visit a zoo or a museum. Report the adaptation of animals that you seldom see outside.

4. With pictures collected from advertisements, magazines, and papers illustrate in your notebook the general statements of this chapter.

5. Study the plants of the city. How have they adapted themselves or failed to adapt themselves to city life?

6. Find and grow plants that are adapted to the dry air of houses and schoolrooms. Learn how certain bulbs may grow.

7. Look back at Chapter Four and decide how the plants and animals mentioned are adapted to survive winter.

III. Test yourself with the following questions:

1. What is meant by *adaptations?*

2. Show how the squirrel's body is adapted to live as it does.

3. For what type of wild life is the dog adapted? How?

4. Select a water-dwelling animal and tell how its body is adapted to water and how a land-dweller is not.

5. Tell the adaptations of each of the following plants to its environment: seaweeds, ferns, weeds in general, cacti, house plants that you have seen successfully grown all winter.

6. How is your body adapted to the life you lead?

7. How are the pets you raise adapted to their present lives? How are they at a disadvantage?

IV. Think out or investigate further.

1. Suppose you were transported to a savage land. How have your present habits made you poorly adapted to keep alive in the wilderness?

2. Suppose your favorite pet were returned to the wild home of its ancestors. How are its present habits poor adaptations for life in the wild?

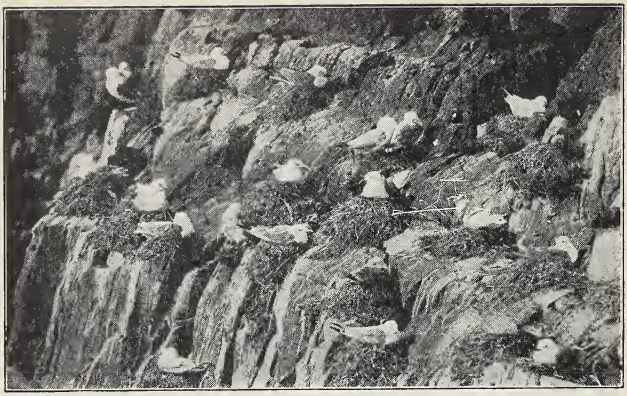
3. How does the aviator overcome his lack of adaptations to the cold, thin atmosphere of great altitudes?

4. How does the Eskimo, whose body does not have the adaptations of the Arctic fox and polar bear, adapt his activity to the polar environment? How did Admiral Byrd's expedition?

5. What ills result because man's body is not perfectly adapted to life indoors?

V. Word list (vocabulary). Remember to add your own words to those suggested.

adaptation adapted



Globe Photos, N. Y.

CHAPTER SIX

REMAKING THE SURROUNDINGS

How certain animals remake their environment. You might walk through a woods in which squirrels had lived for years without seeing a sign of them unless you happened upon a pile of gnawed nut shells or pine-cone scales. But if civilized men move into a piece of woods and live there, you know it as soon as you see the woods, and you can recognize such a place years after the men have moved away and the woods have grown again. Few animals make deliberate changes in their environment. It is true that a herd of cattle or of buffalo will eat down the grass and tramp the sod

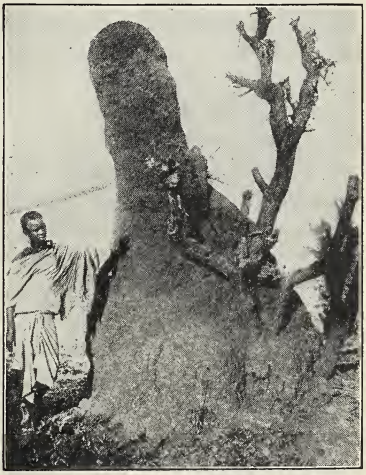


Hugh Spencer, Chester, Conn.
Prairie dogs change their environment by bringing subsoil to the surface

into a muddy or dusty mass. Sea birds cover a rocky island with their nests, and perhaps destroy every bit of vegetation, as in the picture opposite. Prairie dogs riddle a prairie, destroying the grass and turning up the bare subsoil. Even a family of woodchucks can spoil the corner of a field.

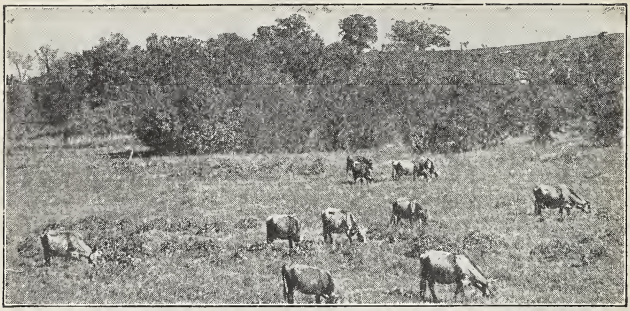
Ants dig galleries below ground and pile up the soil in sandy hills. Termites in Africa and Australia build elaborate, hard "skyscrapers" in which to dwell. Termites in our own country eat out the interior of wood beams and floors until the buildings are dangerous for human occupation. These tiny animals are making extensive alterations in their environments.

A pair of beavers will move into a small brook and select the best place in the brook bed where a dam will make a lake. They cut down trees, drag their branches to the stream and build a wooden dam, laying the branches, butt end downstream and twigs upstream. Between the twigs and branches they plaster mud and weigh the whole dam down with big stones. The dam when completed serves just about as well as any made by man. As the colony of beavers grows, the dam is made bigger, and the pond grows. Here is an instance



International News Photo, N. Y.

The termite engineers build skyscrapers for their cities



Globe Photos, N. Y.

The forest soon covers cleared land unless it is kept back by man or animals. Trees change their environment

of animals deliberately changing their environment extensively to serve their purposes of life. Few animals, however, show the evidence of choice, intelligence, and skill of the beaver.

How plants change their environment. Plants, too, change their environment. Grass and weeds starting on bare ground gradually build a sod that holds the ground from washing away in the rain. When a forest develops on an old farm, a new environment is created by the trees. Grassland animals depart. Grasshoppers and field sparrows go. No longer does the environment enable them to make a living. Then among the trees other animals move in. Forest insects appear. Forest birds hunt the insects—woodpeckers, chickadees, and kinglets. Forest animals make their homes and hunt food—squirrels, wood mice, and porcupines. Plants thus may change their surrounding to such an extent that neither the former plants nor their animal associates can live in the new environment.

Perhaps you have seen a pond that is gradually being filled up by the growth of plants. Bushes,



Allen from Ewing Galloway, N. Y.

Ponds are filled up by soil that is washed into them and by generations of vegetation. Plants are here changing their environment

reeds, and grasses grow out from the shore. The roots hold together the dead leaves and grass and any soil that is carried in by wind and waves. Further out in the water, pond lilies and other deeper water plants die down each winter and their dead leaves and stems are added to the mud on the bottom. Gradually the lake gets shallow, and the shore moves outward. Fishes and turtles may be crowded out of a home. Ducks can no longer find food and a place to build a nest, and they fly to other ponds. Even the muskrat and frog may finally have to abandon the old home and journey overland to another pond or a stream. Grasshoppers, butterflies, and crickets, field mice and rabbits come in, and after them come hawks and foxes for their prey. The old environment has changed to a new one.

Of course, neither plants nor most of the animals intend to change their environment. A few animals apparently do intend to change things to make them more safe. The beaver certainly seems to understand what he is doing. The woodchuck selects a spot to dig his burrow where he can go under a rock or big root where a dog or a fox would have a hard

time digging him out. But few animals seem to think far enough ahead to make extensive changes for their own benefit.

How man changes his environment. How different it is with man. The early settlers in America set out to change the forest into farms. They cut down and burned the great trees that had covered the land. Out on the prairies in later days they plowed under the grass and planted corn and wheat. In still later days, they led water from the mountain streams to irrigate the desert. Men build terraces on the mountain sides and plant vineyards, gardens, and rice fields. Even more striking changes in environment occur where men have built cities on land where deer and bear, or buffalo and antelope roamed.

Civilized man, with his great machines, changes the environment very rapidly, but our ancient ancestors and the primitive peoples of the tropical forest and the great deserts had brought changes to their environments many centuries ago. The battle of the primitive people against their environment was slow and weary. The Egyptian peasant carried out basketfuls of desert sands from his fields only to have the wind blow it back again. The tropical native hacks and burns the trees and vines only to have his garden patches smothered in a few short weeks if he wavers in his eternal battle with the forest. Even in our own country unused fields on abandoned New England farms are rapidly returning to forest. To keep the environment under control we can never cease in our battle with the forces of nature, living and nonliving.

Civilized man uses the forces of nature to control other forces of nature. Jetties built into the river increase the current of the stream and make the river dig its channel deeper. Grasses, bushes, and trees are planted on sand dunes to bind the sands against the



The U. S. Dept. Agriculture

Above. Irrigating an alfalfa field



Ewing Galloway, N. Y.

At right. Terraced orange grove in California

Below. Carefully planted pine forests prevent erosion of sandy soil

Underwood and Underwood, N. Y.

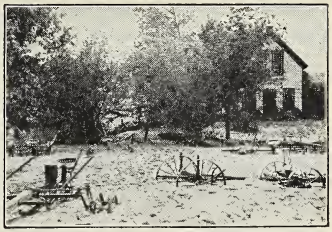


wind. Wasps are brought from Japan to fight the Japanese beetle in America, and beetles are brought from Europe to fight the gypsy moth. Forests are planted to hold the soil on the mountains and control the water supply. Man uses plants, animals, and nonliving things of nature to control his environment.

Just as plants and animals sometimes suffer from the changes that they bring about in their natural environment, so man also sometimes suffers. Destroying forest on the mountains helped bring floods, and floods bring destruction to the lowlands. Growing the same crop on the soil year after year without adding fertilizer, so changes the soil that the farmer gets only a poor crop. Shutting out the fresh air and sunshine from cities, and crowding people together in unsanitary houses and subway trains brings ill health and disease. Too often man has changed the environment in ways which weaken and may eventually destroy him. Science is showing how the environment may be changed to benefit man without bringing disaster and death to thousands.

Certain necessary factors in man's environment he can change little or not at all. He must have air. Although the chemist can make air, he cannot make enough to support a city. Man can pollute the air indoors and out. He can prevent much of this pollution without destroying his factories or even losing money by the changes. He can clean the air and change its temperature and moisture for use indoors, but he must depend upon his environment for his supply.

The chemist can create water, but not in paying quantities. Man must find water ready made, but he changes it for better or for worse. The chemist can change certain foods into certain other kinds of food, but he cannot make food to support a city. Only



Ewing Galloway, N. Y.

Rubbish left when a flood subsided

green plants can make food. Man must find his energy in the forces of nature, although he can change it from one form to another. He can change many of his supplies from one form to another, but he must get the raw material in nature. He must find iron ore, copper, lead, and the other metals. So man may control his environment to a very considerable extent, but he is absolutely dependent upon his environment.

How to Learn about Remaking the Surroundings

I. Read the chapter.

II. Observe the remaking of an environment.

1. Take a hike through the woods and fields or through the park or along the shore to search for evidence that animals and plants are changing their environment. Look for a piece of bare ground that plants are invading. Where stone has been dumped or the ground scraped bare around an old quarry, is a good place to find plants again moving in to cover the bare ground. You will find similar places on a railroad bank or on a road cutting or a vacant lot that has been stripped of its weeds by building operations near by. Along the creeks and rivers you may find sand bars and bare shores where the current has changed its course, or flood plains that were covered with mud. Study these areas and the areas near by which show how vegetation will eventually make them look. Write a report and, if you have a camera, take pictures to show the bare area and the ground that has been covered by plants. Search for the animal inhabitants, from insects and worms to birds, rabbits, and large animals. In your report tell how the land was laid bare, what plants are beginning to invade

it, what the land will be like when it is again covered with vegetation, and how the animal population is changed with the plants.

2. If you cannot go to the woods and fields, try the museum.

3. Select pictures to paste in your notebook, showing the changes in environment brought by plants and animals.

4. Study how man has changed your environment. Learn what the conditions were before the land was settled. What changes were made before the land became as it is at present?

5. What features of your environment created by man are distinctly bad for you? What further change is needed to make the environment better for you in every way?

III. Test yourself with the following questions:

1. Mention several animals that bring little or no changes that you can notice to their environment.

2. Mention some animals that bring unintentional changes in their environment.

3. Mention some animals that seem to intentionally change their environment for their own benefit.

4. Mention two different kinds of environments that are changed by growth of plants.

5. How does the change in environment produced by plants affect the animal population?

6. Tell some changes that man has made to improve his environment.

7. Tell some changes produced by man that have harmed him in unexpected ways.

IV. Think out the answers to these questions, or find them by further investigation.

1. What factors in your home or school environment are unfavorable? What changes should be made?

2. What changes in your home or school environment would make it more favorable for plants and pets?

3. What environments on the earth has man not been able to change to any noticeable extent? Have any other living things made changes in these environments?



UNIT III

HOW WILD THINGS PREPARE FOR WINTER

IF YOU have had a taste of it, you like to hike in the open country. It is perhaps a bit of the Indian in you as in the hunters and fishermen and those who tramp to study birds, trees, and insects. There is fun and science too in turning over the stones along a brook, in pulling the bark from dead logs in the woods, in observing the birds and the trees. Can you name the animal whose footprints you see in the mud along the creek? Do you know the poison ivy, the poison oak, and the poison sumac that have leaves that start fire in your skin? Do you know the sweet birch, sassafras, and peppermint that have flavors you enjoy on your hike?

Do you know why the apple trees and cherries grow along the fences in the unused field? Do you know where the field mice go in the winter? Can you name the birds that are busy getting a living in the winter woods? Do you know why many of the birds that are singing about us in summer go away to the south in autumn while others stay through the snow and ice? Where are the insects in winter and where do so many come from the following spring? Why does the muskrat, imprisoned under the ice of the pond, not drown? Do you know wild creatures that gather a harvest in the fall and store it to use in the winter season? Do you know how the trees, the weeds, and the delicate woodland flowers get ready for winter?

Some of these questions will be answered in this unit. For the answers to others you must go into the woods, through the fields, and along the brooks in autumn and winter.



Globe Photos, N. Y.

CHAPTER SEVEN

FIGHTING THE WINTER

How plants get ready for winter. In autumn, fields that the farmer has allowed to go to tall weeds are bright with flowers. In the woods, too, bright flowers are everywhere among the trees. Most of these flowers bloom on coarse weeds. All summer long these weeds were growing tall and strong without blossoming. Now they tower above the grasses and smaller plants and spread their bright blooms in the sun where the bees find them.

Fall flowers fade, and seeds appear in their places. The goldenrod has a fluffy head instead of a head of golden flowers. Soon the fluffy head breaks up, and small seeds fly away in the wind, each seed carried by a little bunch of hairs like tiny wings. Other weed seeds hook a ride on your stockings with small stiff hooks. Still other seeds are shot out by little springs or are shaken out by the wind from their seed houses or fruits. Other seeds, again, are inside juicy fruits which birds and animals eat and so scatter the seeds about. Autumn is the season for scattering seeds.



H. Armstrong Roberts, Phila.

In autumn as the food supply of the leaves goes down into the trunk, foliage changes into vivid reds and yellows and glowing bronze and orange. Thrifty nature then uses the fallen leaves to enrich the soil and to protect dwellers in the soil.



A head of goldenrod gone to seed

Next month the weeds stand withered and brown. They are dead. But their seeds, now scattered and hidden down among the roots of the grass, are still alive, though sleeping. Storms with snow and ice break down the dead weed stalks, but they cannot harm the sleeping seeds. Each seed is wrapped around with its snug seed coat and sheltered by the covering of dead grass and weeds. The roots, too, of many kinds of weeds and grasses do not die in winter but rest safely under the ground. The snow covers over the dead plants, the sleeping seeds, and roots. Snow shuts out the cold wind as the snow house of the Eskimo shuts out the arctic blizzard.

How trees prepare for winter. Trees, too, scatter their seeds, but the trees do not die. The heavy bark protects them from the cold wind and the icy storms. The leaves of many trees, like the oaks and maples, cannot live in the northern winter. As the cool nights come, the trees prepare to drop their leaves. During the summer days the leaves were busy making food for the plants, in a way that we shall study later. When the cool days come, the food that is still in the leaves goes down into the branches and trunk of the tree. This food will help to keep the tree alive during the winter, and next spring will feed the young leaves as they unfold from the buds. When the food goes out of the leaves in the fall, the leaves change color. The green changes to yellow and often to brilliant red.

The red and yellow leaves are of no use to the tree, and the tree prepares to shed them. Across the stem of each useless leaf, just where it joins the twig, a layer of cork grows. The cork keeps the sap from

passing into the leaf as cork keeps water from flowing out of a bottle. A breeze tears off the leaf, or it falls lightly away. The million wounds left by the fallen leaves are sealed with cork, so that there are no open wounds through which the sap could drain away and cause the tree to bleed to death.

The dead leaves that float down to the ground still have work to do, for nature does not waste dead stuff. Perhaps you have seen gardeners pile dead leaves on their bulb beds to protect them during the winter. Mother Nature does the same thing. Below the dead leaves of the forest are the bulbs and roots of early plants that open when the bright spring sun warms them. The heavy coating of dead leaves and the blanket of snow that covers them keep out the cold winds and help keep heat in the ground.

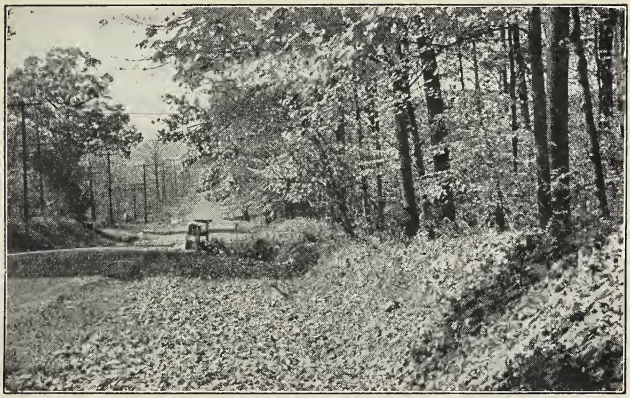
How wild animals get ready for winter. Watch the wild animals in the autumn. Like campers who pile up the warm leaves for their beds by their campfires, the wild animals, too, use the warm beds of leaves. Wood frogs, toads, beetle grubs, worms, and still other animals burrow in the soft ground under the dead leaves and spend their winter in a kind of sleep or stupor.

When you hike through the leafless trees and bushes on a winter day, you will sometimes see a bird's old nest piled high with dead grass. Examine it and be gentle. A little wood mouse may come running out and down the branch. The nest is his winter home. If the storms do not tumble it down or an enemy does not tear it to pieces, it will keep him snug until spring. The nest of twigs and dead leaves all lined with soft grass



Hugh Spencer, Chester, Conn.

Notice the leaf scars on this twig



Boyer from Philip D. Gendreau, N. Y.

The leaves piled upon the ground protect roots and seeds during the winter and furnish nourishment for the plants as they decay

and plant fibers, shuts in the heat from his body and shuts out the winter wind. Snow piling up on top of the covered nest makes still better protection.

Down among the tufts of dead grass on the ground you may find the nests of field mice. You often see them when you hike in early spring as the snow melts away and shows tunnels that the mice made under the snow and dried grass. The hard crust of snow kept them safe from their great enemies, the owls and foxes. They built their tunnels around the grass roots and among fallen seeds that make their winter food.

Around stumps in the woods you often see in the snow the tiny footprints of wood mice that have ventured out on the winter nights. And you may find the track of a fox going from one stump to another as he searched for his midnight meal. Often you can follow for miles the tracks of a fox on his hungry hunt before you find marks in the snow that tell where he pounced on a mouse. You may find a drop of blood and a few feathers that tell where he surprised

a pheasant or a farmer's chicken, for hungry foxes often come around the farmhouse on a winter night. You do not need to live in the wilderness to see fox tracks. On the farms just outside our big cities foxes are often plentiful. They are cunning and keen and have learned to live close to man yet live wild and free.

On your tramp in the autumn forests you may—if you are not too noisy—often hear nuts or pine cones falling as a squirrel cuts them off the branches overhead. Then, if you sit down patiently on a fallen trunk, you may see the squirrel come down the tree and pick up the nuts that he cut off. You may see him carry them to a hollow log to hide them, or he may bury them, one here and one there, in the ground. You may also see a squirrel carrying dead leaves, one or two at a time, or a twig with brown oak leaves, up a tree and out on a branch to a crotch high above the ground.

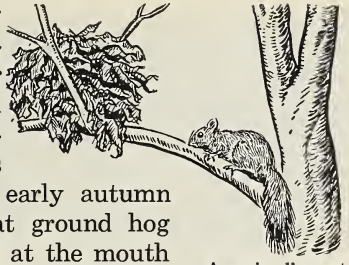
There he builds a great bulky, warm nest for the winter days. If he can find a snug hole in a hollow tree, he builds himself a nest there too. When the storms howl, he lies in his nest. When the weather is not so bad, he comes down and digs out nuts that he has hidden. You may often find his diggings in the snow, and the scales of pine cones on his favorite stump. Toward the end of winter, when his stores of food are running low or when he wants a change of diet, he bites out the large buds of the trees and digs the spring bulbs from the ground.



A field mouse and its nest



These footprints were made by (1) wood mouse,



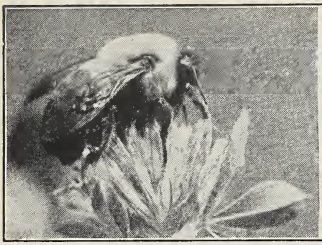
A squirrel's nest

Sleeping the winter away. While foxes, rabbits, and mice hunt their winter meals, ground hogs and ground squirrels are asleep in burrows underground. In the early autumn you may see a big, fat ground hog sitting lazily in the sun at the mouth of his burrow. When he sees you he turns and tumbles in. Then wait patiently and quietly, and you may see him stick his head out and look around in the world. If he sees you, he retreats within his tunnel, with a queer, whistling bark. When the cool fall days come, he retires to his bed chamber and curls up to sleep. His fat supplies the food that keeps him alive until the warm days come again and he can get fresh plants to eat. This long winter sleep of animals is called *hibernation*, from a Latin word which means "winter." Many animals hibernate, bears in dens among the rocks or under fallen trees, toads under the loose dirt and dead leaves, snakes in holes in the ground and under rocks, some insects under bark and in old stumps.

Death comes with winter. Watch how the insects get ready for winter. On your fall hikes you will find insects in abundance. The bumblebees are big and clumsy. The honeybees are as busy as in the bright summer days, laying up food that will last all winter. And butterflies are fluttering about the tall flowers. After the first frosty night, insects rapidly disappear. The next day you may find many



(2) fox, (3) muskrat, (4) a bird



Hugh Spencer, Chester, Conn.
Bumblebees winter under bark and logs

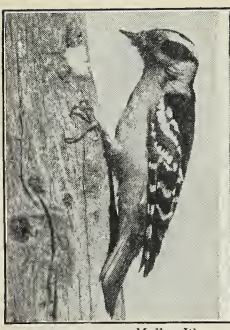


Hugh Spencer, Chester, Conn.
Young moths winter in cocoons

crickets in the warm sun on a path through the grass. They are sluggish after the night's frost and you can easily gather a jarful for study at school. You will find bumblebees hanging still on the flowers and you may easily scoop them up in a bottle. At the beginning of winter all bumblebees except the queen die. She hides away underground or in a crack in an old stump, often coming out in warm days in winter. Next spring she builds a new nest, lays her eggs, and starts a family.

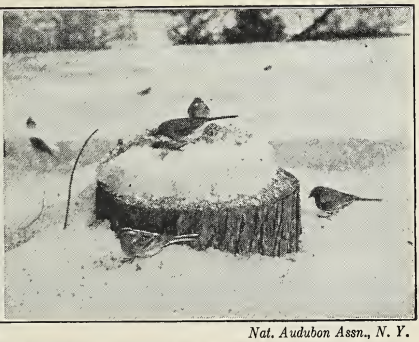
Most butterflies and moths die when winter comes. You may see cocoons hanging on bushes and on the trunks of trees during the winter. Inside each cocoon is a young moth that will make its way out when the spring sun warms it. Mosquitoes and flies die, but the eggs that they have laid lie unharmed by the winter to hatch out in the spring.

Birds in winter. Birds are everywhere about you in autumn. Many are from the north where they have raised their families, and they are on their way farther south. Some stay with us all winter. You may often see them if you look for them on your winter hikes. On the tall weeds standing above the snow, tree sparrows, snowbirds, and goldfinches are gathering seeds. On the bark and twigs of trees creepers, nuthatches, and chickadees are hunting



Muller, Ithaca

The downy woodpecker eats grubs and other insects in the winter



Nat. Audubon Assn., N. Y.

Juncos and sparrows eat weed seeds during the winter

cocoons and insect eggs. Woodpeckers are drilling through the bark for beetle grubs that feed on the inner bark. Crows are often hunting in the fields, and toward evening may be seen flying high in the air toward some spot in the woods where they gather in crow roosts to spend the winter nights.

Game birds are about in autumn and winter. Where bobwhites—also called *quail* and *partridge*—are protected during most of the year, they become numerous. Flocks of a dozen or two start suddenly with a whirr of wings from under your feet as you tramp through a field of dead weeds. Then if you wait, you will hear across the next field the lonely, far-away call as the flock is called together again. They are valuable birds to the farmer, eating up vast quantities of weed seeds and insects. In the spring their cheery "bob-white" call tells the farmer that these friends are helping him in the field. They are song birds and helpful birds, yet in many places they are game birds, slaughtered for sport.

Through the weed field, you will often hear the harsh cry of pheasants or you may be startled by the whirr of wings as the big birds rise and dash into



Acme Newspictures, Inc.

Many game birds and animals are prevented from starving during the winter by being fed at feeding stations

the thickets to hide. They blend so perfectly with the ground and the dead plants that you rarely see them until they rise. Most of the pheasants that are with us now have been introduced to kill for sport. We long ago wiped out from most of our farm lands and neighboring woods the magnificent native pheasants, or ruffed grouse—sometimes called *partridge.* Our present pheasants are bred on game farms and turned loose to furnish sport.

Deep snows that last all winter are hard on the quail and pheasants as well as other seed-eating birds. The food is buried where they cannot get it. Cold seems to do them no harm if they can get food, but they cannot survive cold and starvation. Buds on the trees furnish some food, but not enough. Long, hard winters with deep snow mean the death of many seed-eating birds. Many farmers, game wardens, and sportsmen's associations spread seed for these birds during the long snowy winters.

Along the streams, in ponds and bays, you may see ducks and sometimes geese. The northern lakes and bays and streams have furnished them summer homes and safe places to raise their broods. In autumn they



Ewing Galloway, N. Y.

Flights of wild ducks and geese are far smaller than they were a few years ago

are on their way south beyond the reach of ice that would shut off their food. Sometimes along the seacoast they delay their southern journey too long and many perish in the ice. Not many years ago, flights of ducks blackened the sky and great rafts of ducks blackened the waters. Now ducks are rare over much of their former territory. The Indians depended largely on ducks during their autumnal flights and prepared large quantities for winter food. Now Indians would starve if they depended on ducks and other native birds and animals.

Winter in the water. When you tramp along a brook in the autumn you will find other creatures getting ready for the cold season. If you reach down into the water and run your fingers under a rock, out may dart a crayfish (or crawfish). As the cool days come on, you will find in the sand and mud little burrows, each surrounded with a "chimney." In each, a crayfish is digging himself a winter home where he will rest until he feels warm sun again.

In the mud and wet sand along the brooks you may find also tracks like those on page 71. Muskrats have been hunting food. They will take a crayfish,



Ewing Galloway, N. Y.

A muskrat's house

if they can, or dig out a fresh water mussel, carry it up the bank, and lay it where it will open in the sun. Then they return for their mussel dinner. Muskrats eat also the roots, lily bulbs, and plants growing in the water or along the bank. If you look just under the water along a clay bank where you see the muskrat tracks, you may see holes leading into the bank. There is the muskrat home. In ponds and swamps, muskrats sometimes build houses like the beaver's, of sticks, sod, and mud, with a warm bed of dead grass inside.

When winter comes the muskrat is safe from the storms. The tunnel from his house leads to the water under the ice, where he may swim around without fear of dogs, wildcats, or owls. All winter long he can search safely for his mussels and lily bulbs. He may sometimes get out of breath under the ice. Then he finds a hole in the ice, especially along the edge of the stream. If he finds none, he blows out his breath against the ice where it is quickly purified. Then he breathes in the air again.

Down in the mud, frogs and turtles are buried in their winter sleep. When the mud freezes, they freeze. In the swift brooks you may see fish darting about all through the winter. In small ponds where the water freezes to the bottom the fish may freeze in the ice as do the frogs in the mud. When the ice melts again, the animals are set free, apparently not harmed by the cold way of spending the winter.

If you turn over the rocks in the brooks even in a city park, you may find more living things. Queer

looking things with two or three long "tails" attempt to scamper away from sight. They are young May flies and stone flies. In the autumn they are tiny creatures, but if you search the rocks in spring you will find they have been growing all winter. When warm days come some of them will turn into flies like those on page 356. Others live on for another year under water. All winter long they manage to find food, little creatures smaller than themselves or small plants, dead or alive. You may find young dragonflies like those on page 355. Attached to the underside of rocks are little stone houses or stick houses of the caddis worms. (See page 355.) Some of these little creatures spin tiny nets at the entrance of the house to catch any little living thing that comes drifting downstream. So they spend the winter to come out next spring as little flies.

Water plants, too, must get ready for winter. Some plants die, and their seeds start new plants the next spring. Others, like the cattails on page 42, die above the swamp, but their stems and roots in the mud remain alive all winter, covered over with ice. Sometimes when you break the ice you find green slimy things that you see in summer time. These are simple plants, cousins of the seaweeds. Under the microscope they are beautiful plants. Many such plants die, but leave microscopic parts, *spores*, that, like seeds, start the plants in the spring.



Hugh Spencer, Chester, Conn.
Green pond scum

Autumn the time to prepare. Through the autumn months the creatures of the wild and the plants prepare for the coming winter. Some fly

to warmer climates, some gather food and store it as the farmer does. Some lay up fat in their own bodies to keep them alive while they sleep away the winter in hibernation. Some must hunt all winter. Most insects just die, new insects coming out from cocoons next year or hatching from eggs that the winter cannot kill.

Man is heated and cooled by the same winter and summer as the wild creature is. He, too, must provide for the cold and hungry season or suffer. Many of the Indians, before the coming of the white man, made poor provision for the winter. Some laid by stores of corn and beans that they had raised. Some gathered the wild fruits of the wood, nuts, acorns, and wild rice from the swamps. They trapped rabbits to make warm winter garments and blankets and used the skins of larger fur-bearers. The Indians of the Plains dried buffalo meat and stored it. But winter was in general a hungry time for the Indians. The early colonists and the settlers in the interior also suffered from food shortage and cold as the Indians did.

Now the white man can produce and store food and other supplies in abundance. Thanks to the discoveries of science, the farmer, the manufacturer, and the government officer often worry because we have too many good things with no market for them.

It is true that there are many people hungry and cold in winter, but the world has enough food for them, enough clothing to cover them comfortably, enough fuel to warm them, and we can build enough houses to shelter them. You will learn in your social studies of the plans for getting the food and other material into the hands of the people who need them. We have the material and can produce plenty more; we have not yet solved the problem of making everyone comfortable.

Things to Do in Learning How Plants and Animals Get Ready for Winter

I. Read the chapter, or you may first do what is suggested in II and then read.

II. The best way to learn is to go out in the fields and woods and see what plants and animals do.

1. Make a collection of the weeds and grasses that you see in bloom in early autumn. If you cannot learn the names of the plants from books in the library or by asking, number the plants and describe them. Press the plants flat between newspapers and boards. Later you may mount the dried plants by pasting them on white paper. Print the name, if you know it, and the sort of place where it grew—swamp, woods, dry field—as well as the date and locality. Later collect the same plants in fruit. Mount dry fruits on paper. Store larger fruits in boxes each with the name and number. You may identify them in the laboratory. Make a collection of fruits to show how they are scattered about by wind, by sticking to clothing, or by animals that eat them. Your class can make a valuable addition to the school museum.

2. Make a list in your notebook of the kinds of animals that you see each day and the number of each and what each is doing. Note also the kind of home each has. With a book from the library and, if possible, a field glass, learn the names of the birds. Note down what kinds you see each day and the number of each. Note also what each kind is doing.

Search for insects week after week. In winter, look for their eggs in the crevices of bark, on twigs, and on weeds. See how good a chickadee you would be. Split open the stems of weeds and look for insects inside. See what you find under dead bark and under leaves on the ground.

Search the brooks as suggested in the chapter. Make notes and report to the class.

3. If you live in the heart of a big city and can find no way of getting out, perhaps you can find something to study in the city parks. If you know where there is a

weed-covered lot or railroad bank, you can find lots of things getting ready for winter there. If you have a museum in your city, and you probably have, study the exhibits there.

4. If you can do none of these, try the library. Study pictures in books and magazines and newspapers. Make a scrapbook by pasting suitable clippings in pages of your science notebook. Illustrate what you have learned by reading this chapter.

III. Test yourself with these questions:

1. Name several ways in which plants spend the winter. When plants die in the autumn, how do new plants start again next year? Plants that live more than one year must keep alive all winter. In many such plants only a part of the plant remains alive. Name some such plants and tell what part remains alive. How does the oak tree make ready to spend the winter? Why is it not necessary for the pine to prepare in the same way? (Think that out.)

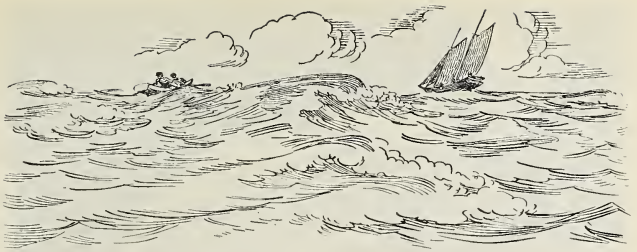
2. Now list various ways in which animals spend the winter, and tell how each prepares for its way.

IV. Think out these questions. They are not answered in the chapter.

1. How does the farmer prepare to spend the winter and care for his crops and livestock? If you live in the city, perhaps your only preparation for the winter is buying a new overcoat, but then someone else must prepare for you. Who takes care of your food and how? Who prepares to keep you from freezing to death and how? Who prepares for your recreation? Who for your education?

2. The Indians, if returned today to the land from which they were removed by the white man, could not now prepare for the winter as they did before the coming of the white man. Why not?

3. Think of the area of land that supplied the backwoodsman of Daniel Boone's day and the land that now furnishes your winter supplies. Which drew from a larger area? Why? No doubt for more than one reason. Think out more reasons.



UNIT IV

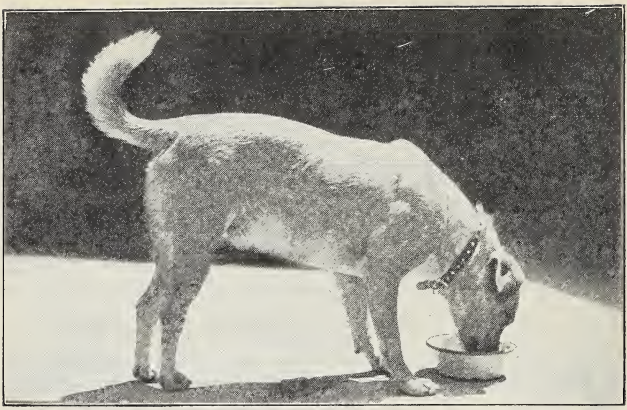
WATER

YOU HAVE known water for a long time—after a fashion. You do not need science to tell you what it does—or do you? You know that water comes down as rain. Do you know why? You have seen water many times. Do you know that it is all around you when you cannot see it in broad daylight? Do you know where the rain pool goes when it dries? Do you know why there is dew on the grass and where it comes from? Do you know why you cannot live without water? Do you know that you yourself are mostly water?

Why are there no land animals as big as whales in the sea? Why can a fish swim so fast? Why do seaweeds have no wood, bark, or roots? How can a clam breathe buried under mud and water? Do you know how many things may be living in a drop of water?

What is the sea good for? What good is water on a mountain top a thousand miles away? Why are lakes where they are? Did you ever see hills traveling down a river? Many people have. Why is the sea salt? What is our government doing to save water and keep the United States from being buried under the sea?

In this unit we shall study the answer to all these questions, and some more. But do not be satisfied by what you read in a book. Go out along the streams and on the hills; go down to the sea and the lakes. Go into the laboratory or rig one up in your cellar or back shed. Discoveries have been made in makeshift laboratories.



Kaufmann-Fabry, Chicago

CHAPTER EIGHT

WATER AND LIFE

The battle with thirst. When you put out food for the birds, put water out too. Birds get thirsty, as you do, but more often, for they are more active. When winter locks up the water supply in ice, it is extremely difficult for birds to get a drink. If you live in the city, it is especially important that you give the birds a drink, for the city is a dry place for the wild creatures and those that have strayed from home. You may have seen a dish of water set out on the sidewalk for the wandering dog by someone who has a kind spot in his heart. Perhaps you have suffered from thirst yourself in a strange city. But there is this difference between you and the animals about the streets. You can go in somewhere and ask for a drink or buy one; birds and stray dogs can rarely find water. The city is a desert to them.

Animals that live in the desert have learned to get along with little water and drink at long intervals. Many of them do not go abroad in the sun, but hide in their homes under rocks or desert plants until the

sun goes down. The desert toads are buried by day. The desert rats and mice are hidden in their nests about the rocks and thorny plants. The desert fox lies asleep by day and hunts for his meal at night. So, also, does the poisonous gila monster. Some desert animals drink very rarely but get their supply of water by eating the desert plants. The camel stores water in his stomach and can go without a drink for several days.

Plants of the desert are also adapted to save water. They must stand in the sun, but many have no leaves, or have leaves only when there is a little rain. Heavy tough skins help them to save water. Many plants store water in their roots underground or in thick stems, like the cactus. Native peoples who live in the desert have learned how to get the water from the thick stems or roots to keep themselves alive. The bushmen of the South African desert bury in the sand ostrich eggs filled with water to use when water cannot be found.

Why living things need water. Try to swallow some dry cracker dust. You choke and sputter, but cannot swallow the cracker dust until it is thoroughly wet. You cannot swallow without water. Have you noticed the saliva trickle from a dog's mouth when his dinner is brought out? A hungry dog swallows so fast that he must have plenty of liquid in his throat. Your food could not digest without enough water. Digested food is food made liquid in water. Digested food could not be carried through your body without water, for it is carried in the blood, which is mostly water. Waste



A gila monster lives in waterless deserts



Almost two thirds of your body is water

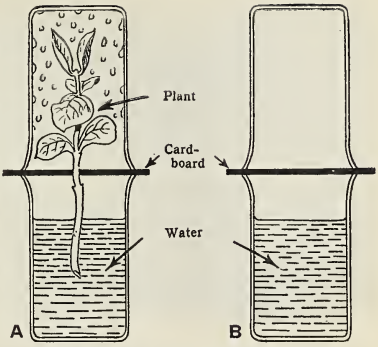
could not be cast out of your body without water. Almost two thirds of your body weight is water. If the water were taken out of your body, you would be as dry and stiff as an Egyptian mummy.

You have seen how quickly cut flowers wilt out of water, and how potted plants droop when the soil dries out. Water helps to hold the plants erect. Food travels through the plant in water, just as food travels in water through an animal's body. The plant can get its minerals from the soil only when they are dissolved in water. Like the animal's body, most of the plant's body is water. A potato is eight tenths water, and a watermelon nine tenths.

In addition to holding water inside their bodies, plants give away much more to the air. A sunflower gives out to the air a quart of water a day. An apple tree gives out thirty quarts a day, one hundred eighty tons of water a season. An acre of beech woods gives out fifteen tons of water a day.

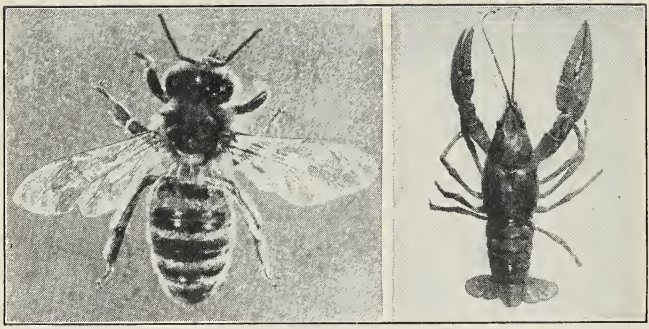
You can show by experiment that plants give out water from their leaves. Put a freshly plucked leaf in a glass of water and cover it with a glass as you see opposite. Set up a second pair of glasses as in B. Set both A and B in the sun. You will soon see the upper glass in A covered inside with moisture. The upper glass in B has no moisture. We say B is the "control." The control has everything that A has except the leaf. Where did the water vapor in the upper glass of A come from? It must have passed up through the leaf stalk and evaporated from the leaf. [The passing of water vapor from plants into the air is called *transpiration*.]

Living in water. Life under water has many advantages. It is not so cold as land in winter, for the ice shuts out the cold wind, and water holds its heat well. Have you ever noticed how long a water bottle stays warm? Have you noticed that the cup of coffee or cocoa may be hot when the meat and potatoes are cold? In horse-and-buggy days the old folks sometimes put a jug of hot water in the buggy to keep their feet warm. Try out the power of water to hold heat as in Experiment No. 5. Water is slow to heat up. You know that the seaside is cooler in summer than the interior of the country. That is because the water regulates the heat. Water dwellers do not suffer from sudden changes of temperature as much as land dwellers.



This apparatus shows how a leaf gives off water vapor

Water is also a great help in getting about. Water dwellers not only travel along as well as land animals, but can travel up and down much easier than most land dwellers. The water helps to hold up an animal. You probably have noticed how easy it is to pick up a big stone in water. A water dweller does not need to exert himself much to hold himself up. Therefore the biggest animals, the whales, are water dwellers. The lobsters and crabs, blood relatives of bees and spiders, have heavy coats of armor, while bees and spiders must trust to their speed for protection. Water supports the weight of the heavy creatures that dwell in it.



U. S. Dept. Agriculture *Hugh Spencer, Chester, Conn.*

How are the bee and the crayfish alike?

How living things are fitted for water life. You know that a fish is fitted, or adapted, to live in water, but you probably never stopped to consider how. Fish were streamlined many million years before automobiles were, and much more perfectly. Their shape lets them shoot through the water.

When you ate fish did you ever notice how much is muscle? All the white meat that you eat, much the bigger part of its body, is muscle. A little wriggle of the body sends the fish like a flash through the water. The fins help it to steer, and keep upright.

The scales overlap like shingles, from the front backward and from the top downward. If you have handled a fish you know that it is slippery and slimy. That helps him to slide through the water and perhaps helps to keep him warm, like the grease that the long-distance swimmers smear over their bodies. The slime helps also to keep out bacteria of disease. Therefore, wet your hands before you handle a pet fish so that you will not rub off the slime. The fish has gills, a special kind of breathing organs to enable him to get the air that is dissolved in the water. There is a picture of them on page 51.

The shape of the fish, the fins, the body nearly filled with muscles, the slimy covering, the gills, are adaptations to his environment or adjustments to his surroundings.

You can easily think out how other creatures are adapted to live under water. The young mosquito has tiny gills like little plant leaves and a tube that it pokes above the surface for air. The clam, buried in the mud, sends up a long neck to draw in the water. Inside its shell the water passes over thin curtainlike gills. In the picture below, hunt for other adaptations to water life.

How plants are adapted to water life. Water plants, too, are adapted for their job of getting a living in the water. Seaweeds hundreds of feet long have no wood to hold them erect. Stiff stems would be broken by the waves. They have no roots, for they do not get their mineral food from the soil, but from the water in which they float. They have no bark to interfere with the absorption of mineral food from the water. Fresh water plants, too, have special adaptations for their water surroundings. Water lilies that grow in eight feet of water have weak stems that could not hold the leaves upright. The water holds them up. Many water plants have air chambers in their stems that act as floats. Plants living in a current have finely divided leaves that offer less resistance to moving water than whole leaves.



Keystone View Co., N. Y.

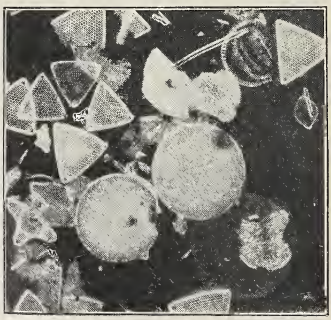
The fish is an example of "streamlining"



Hugh Spencer Chester, Conn.

The finely divided leaves of this water plant allow the water to flow freely through them

Many water plants and animals are so small that they can be seen only with a microscope. If you have a microscope at school or at home, scoop up some stagnant water with a little of the mud and dead plants that lie on the bottom, carry it to school or home and let it settle in a glass. If you put a drop of such water on a glass slide and examine it under the microscope, you may see some microscopic animals composed of only one cell each. The picture shows some plants that you may see. There are many other interesting types. These minute creatures live only in water, getting their food and their air from it. If the water dries slowly, many of them are adapted to dry with the water. They surround themselves with tough walls which prevent complete drying. They may then blow around with the dust until they alight again in water, whereupon they come out of their tough coats and move about.



Black Star, N. Y.

Some living plants found in a drop of water under a microscope

Things to Do in Learning That There Can Be No Life without Water

I. Read the chapter.

II. By experiment and observation study the need of water.

1. Put out a birdbath or a dish of water and count the number of times that birds come to drink. Even in the city you may be surprised at the large number. If you live in a city, count the number of places that you see where a bird or a stray dog could get a drink.

2. Study how plants are built to live in the desert with little or no rain. If you live near a desert, go out and see. If you live in a big city, go to the botanic gardens and museums and study the exhibits. If you can do neither of these things, make a collection of pictures of desert plants. If you cannot cut them from papers and magazines to paste in your notebook, study them in books and magazines. Notice the following structures of the desert plants: (a) Leaves. How do they compare with the leaves of plants that grow where there is more rainfall? (b) Their skin or bark. Compare it with other plants. Is it thick or thin? hard or soft? shining or dull? hairy or smooth? How do these characters help the plant? (c) Roots. Are they long or short? thick or threadlike? (d) Does the plant have any structures to protect it from animals? (e) List the characters that help the plant to gather and preserve water. (f) When does the plant bloom? Can you decide why it blooms at that time?

3. Experiment No. 2. Try the experiment of swallowing some dry cracker dust or flour. What must you do before you can swallow it? What does this experiment show you about a value of water to your body?

4. Experiment No. 3. What percentage of a potato is water? Weigh the potato. Cut it in very thin slices. Dry them thoroughly. Weigh them again. Find the loss of weight and calculate the percentage. The weight of the water multiplied by 100 and the result divided by the weight of potato gives you the percentage. Write a report of the experiment, using the following headings: Question, Materials, Procedure, Observation, Conclusion.

5. Learn by the following experiment (EXPERIMENT No. 4) how water passes out from living plants. Set up the materials as shown on page 85. Write the record of the experiment in your notebook under the same headings as in the last experiment: Question, Materials, Procedure (make a drawing of the apparatus and tell how to use it), Observation, Conclusion.

6. Learn by EXPERIMENT No. 5, which cools faster, water or sand. Take two tin cans exactly alike. In one put a weighed quantity of water and in the other the same weight of sand. Put a thermometer in each and heat to the same temperature. Then allow both to cool to room temperature, taking the temperature every five minutes. Write up the experiment in your notebook as before and record the results in a table.

7. Learn by EXPERIMENT No. 6 how water affects the weight of a stone or piece of iron immersed in water. With a spring balance weigh the stone in air and then suspend it in water and weigh it again. Write up the experiment in your notebook as before.

8. Learn by observation how a fish is adapted or suited to live in the water. Watch a fish in an aquarium or one in a brook. What fins are moving when it is not swimming forward? What good do these fins do? Why does the fish keep opening and closing its mouth? What other openings keep time with the mouth? Make the fish swim forward by thrusting your finger behind it. What movement of its body sends if forward? In a dead fish learn how much of the body is muscle, the white meat. Is the fish strong for its size? Open the gill covers and see what gills look like. In which direction do the scales overlap? Why?

9. Learn by observation how water plants are suited to their life in water. Compare the stems with those of land plants. How do you account for the difference? Compare the leaves that live entirely under water with leaves that live above water. Why the difference?

10. If you have a microscope available, hunt for some of the microscopic plants and animals as told on page 88. Make drawings of all the kinds that you find.

III. Test yourself with these questions:

1. Tell how at least one desert animal is built or adapted to live days without drinking. How do some other animals behave to avoid danger of death by thirst?

2. Describe the structure of desert plants that enable them to resist death by drought. Point out the structures in pictures you may find.

3. What did you learn by Experiment No. 3? How does the potato compare with other plants and animals?

4. What did you learn by Experiment No. 4? Tell how much water is given out by some growing plants. (Think this out.) How do desert plants reduce the loss of water?

5. What did you learn by Experiment No. 5?

6. What did you learn by Experiment No. 6?

7. List all the advantages that you can of life in water.

8. Are the largest living animals in the sea or on the land. Why?

9. List all the ways in which a fish is adapted to live in water. How does it breathe? How does it swim? How is it covered? Think this out: Compare the fish with a land animal, such as a cat.

10. Tell how the plant on page 88 is fitted to live under water.

11. How are the microscopic animals in rain pools adapted to survive when the pools dry up? How do they get into the pools?

IV. Think out the answers to these questions. They are not answered in the chapter.

1. How has man provided for life in crossing the desert or in dwelling there?

2. List all the disadvantages of living in water.

3. Think of some other water animals and tell of some structures that especially fits the animal to live in water. You might take, for example, an oyster; a turtle; a beaver.

V. Remember your word list. If you met some strange words in this chapter, add them to your word list in your notebook.



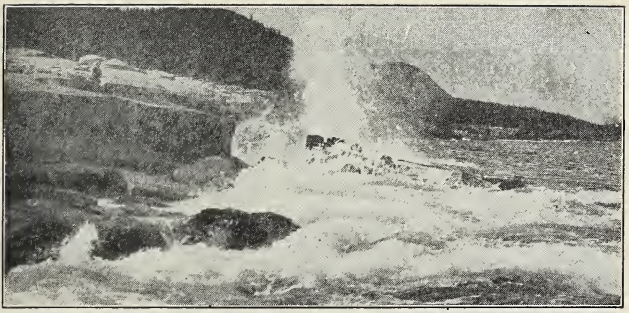
Douglas-Gendreau, N. Y.

CHAPTER NINE

WATER IN THE AIR

Showing there is water in the air. As the rain poured down, did you ever sit and wonder where it all came from? What made it rain, and what made it stop? Did it have to rain just when you were on a hike or a picnic?

Rain comes from the air. You see it come. By a simple experiment you can show that water is in the air when it is not falling as rain. Place a mirror or a dry glass tumbler in the refrigerator. Let it stay until it is thoroughly cold. Then take it out into the air. You will see mist or cloud appear on the glass. That cloud is tiny drops of water. Sometimes you can see the drops run down the glass. If you try this experiment on a cold winter day when it is colder outdoors than in your refrigerator, the experiment will not work. On cold days bring the cold glass into the room and see that there is water in the air of the room. People who wear eyeglasses demonstrate this when they come indoors on a cold winter day and their glasses cloud over with moisture.



De Cou from Ewing Galloway, N. Y.

Forests and the open sea are sources of water for the clouds

Where the air gets its water. With water falling out of the air throughout the year, a great deal of water must also be going into the air from somewhere. When a shirt dries out on a clothesline, the water goes into the air. Plants, too, send water into the air. If you think of the great forests, and the farms, and the great plains covered with grass and other plants, you will see that plants contribute a great deal of water to the air. A large oak tree sends several tons of water into the air each year, water that it took from the soil through its roots. A field of grass or clover also sends several tons of water into the air from each acre. Practically all the land, except the polar regions and parts of the desert and the high mountain tops, is covered with plants.

You have seen rain pools dry up, and if you have lived in a region that suffered with drought, you have seen ponds and small lakes dry up. This water passed into the air. Rivers and brooks also are giving water into the air. The greatest source of water for the air is the ocean. Three fourths of the earth's surface is covered with ocean. From the icy polar oceans to the steaming equator water is passing into the air.

What makes water go into the air? If you want your shirt to dry in a hurry you hang it near the fire. Perhaps, too, you have seen the roads dry out rapidly in the sun. If you set a pot with an inch of water on the table it will dry out in several days or a week. If you put the same pot with an inch of water on the fire, it will boil dry in a very short time. Heat increases the rapidity of evaporation.

If you are a good camper, you know that your wet shirt will dry more quickly in the wind than out of the wind. Your mother and washerwoman know also that clothes dry more rapidly on windy days. In fact, clothes will often "blow dry" on a damp, windy day, provided rain is not continually wetting them again. Roads, too, dry out rapidly in the wind. A clear, windy day is the best day to dry out roads and baseball fields, as well as the family wash. A current of air increases the rapidity of evaporation.

Vapor. You can see that the shirt or ball field is drying, but you cannot see the water going into the air. We say that the water *evaporates* or becomes *vapor*. You cannot see water vapor. There are many other vapors that you cannot see. When you open a bottle of ammonia and let it stand on the table you cannot see its vapor, but you know that it is in the air because you can smell it. When gasoline is spilled on the ground, it evaporates and becomes invisible (cannot be seen), but you can still smell it.



How does the water get on the outside of the pitcher?

What makes water come out of the air? Did you ever get your shoes wet in the dewy grass on a summer evening? Perhaps you have heard it said



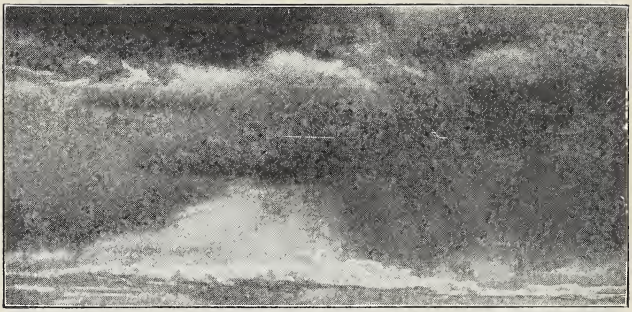
H. Armstrong Roberts, Phila.

How does wind help clothes to dry?

that "the dew falls." That is not quite correct. Let us see what actually happens. Recall the experiment with the cold mirror. You could see no water vapor in the air, but when you brought the cold mirror out of the refrigerator, you saw a mist of liquid water gather on the cold mirror. The mirror cooled the air around it and the water vapor in this air became liquid. When water changes from a vapor to a liquid, we say that it *condenses*. Water vapor condenses upon cooling.

On a summer evening when the sun goes down, the grass cools off rapidly and in turn cools the air about it. The water vapor in this air then condenses on the cool grass just as it condensed on the cold mirror in our experiment. The moisture that condenses on the grass and other objects on the ground is *dew*. When the thermometer goes down to 32° F. water freezes. If the temperature of the air is below 32° F. when the water condenses, the moisture is deposited as ice, and we call it *frost*.

As air rises above the surface of the earth, it becomes colder. It may rise so high that the air is cooled far enough for the water vapor to condense



Ewing Galloway, N. Y.

Try to imagine the immense quantity of water required to make these huge clouds

into tiny drops as it did on the cold mirror. If the drops are very tiny, they will float in the air, and form a *cloud*. Sometimes the air close to the earth becomes cooled and the vapor condenses into tiny drops of water that float in the air forming a *fog*. The tiny drops condense around little particles of dust floating in the air. Sometimes the tiny drops of water grow as more moisture is condensed around them. They may finally become so heavy that the air can no longer support them. Then they fall as *rain*. If the temperature is below 32° F. as the moisture condenses, it becomes *snow*, which is made up of tiny crystals of ice.

Winds help rainfall. You know that wind helps to dry the shirt on the clothesline and the rain pool by the road. It helps in the same way to evaporate water from streams, lakes, and oceans. It carries the water vapor away with it as it blows over the land and the sea. If the wind comes to a mountain range, it may blow right over it, but it may need to rise very high. As the wind rises, it cools. If it carries enough water vapor and if the mountains are high, the air may be cooled far enough to cause condensation of the vapor to form clouds. In mountain regions one

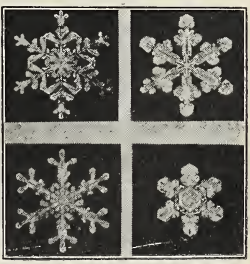


Philip D. Gendreau, N. Y.

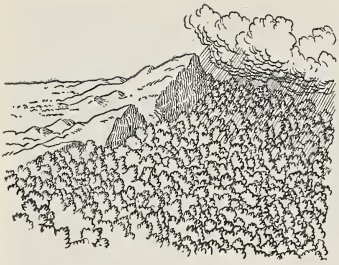
A cloud banner is the mountain weather vane, showing the direction of the wind. The water vapor forms a cloud when the air is chilled.

often sees clouds about the mountain tops when there are none elsewhere. Sometimes a cloud streams away from one side of a mountain top showing us the direction of the wind up there. This sort of cloud is often called a *cloud banner*. The banner forms only when the air is chilled going over the mountain.

Often the drops of water in the cloud grow so rapidly that they fall as rain. Mountains are often cloudy, foggy, and rainy regions. Very often, as in the high mountains of our West, when the lowlands are hot and dry the mountains are having rain. When the winds blow over a high mountain range, they sometimes lose so much rain as they rise that there is little left to fall after the wind has crossed the mountain. In addition, also, the wind coming down the mountain gets warmer and therefore water does not condense. On the lee side of high mountain ranges (the side away from the wind) there is, therefore



Snow crystals



Why is there forest on one side of this mountain but not on the other?

often dry land while the windward side (the side against which the wind blows) is rainy.

Air also rises where there are no mountains. We shall study about this rising later in our course. When the air rises high enough over the low country, clouds are formed just as they are over the mountains.

When the drops of water become too heavy for the air to support, they fall on the low country as rain just as in the mountains. On hot summer days the air often rises very rapidly and so much water vapor is condensed that it falls as heavy thundershowers.

The water cycle. Through ages water has been continually evaporating from the sea, lakes, streams, from plants and from bare countryside. It condenses in the cooler air and falls as rain. Round and round it goes, down to the sea and up again. Its course down to the sea as liquid water and up into the air as vapor, only to return again as liquid water, forms the *water cycle. Cycle* is from a Greek word meaning "circle."

Things to Do in Learning about Water in the Air

I. Read the chapter.

II. Do these water experiments:

1. Perform the experiment described in the chapter showing that there is water in the air. Write it up in your notebook as you did the experiments in the last chapter, using the headings: EXPERIMENT No. 7, Question, Materials, Procedure, Observation, Conclusions.

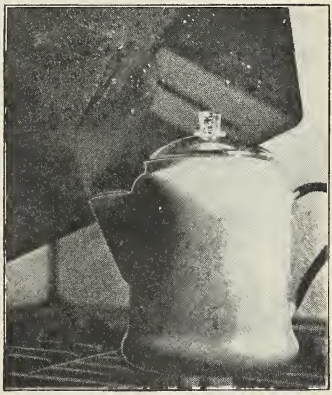


The water cycle. Trace the course of water in the cycle.

2. EXPERIMENT No. 8A. Set a saucer of water on the window sill outside the window. Set another containing the same quantity of water on the window sill inside the window. Set also two narrow vessels such as a test tube or a narrow vase containing the same quantity of water beside the two saucers. Time them to see which dries out the quickest. Write up this experiment as you did the others. In your conclusion state the conditions that you discovered that increase evaporation.

3. EXPERIMENT No. 8B. Wet two handkerchiefs. Time the rate of drying over a radiator or other source of heat and in a cooler part of the same room. Write the experiment in your notebook.

4. EXPERIMENT No. 8C. Wet two handkerchiefs and determine the time required to dry when one is hanging on a line and when one of them is waved in the air or blown by an electric fan.



Sally Pepper, Phila.

Why do drops form on the cold metal?

Write the experiment in the usual form in your notebook.

5. Experiment No. 9. Perform the experiment shown at the bottom of page 99. Make a report of the experiment in your notebook.

6. Study carefully each figure in the chapter and answer the questions asked about it. Decide what each figure shows about water in the air, why it goes into the air, or why it comes out.

III. Test yourself with these questions:

1. What did you learn by Experiment No. 7? Why do eyeglasses become covered with steam when their wearer comes indoors on a cold day?

2. Is there water in the air about you at the present time? How could you show it?

3. Where does air get the water that it contains?

4. Write down the list of conditions that you discovered by Experiments 7, 8, and 9 under which water evaporates readily.

5. What makes the water vapor of the air condense? How can you show that by experiment?

6. How much would you weigh if all the water were taken out of your body? Figure it out from the facts that you have learned.

7. Tell one reason why a mummy does not decay.

8. Recall Experiment No. 9. Is the water vapor in the clear area just at the end of the spout or in the cloud a little farther out? What forms where the cloud strikes the cold plate?

9. Look at the picture on page 99. Where does the vapor condense? Why?

10. What do you mean by "evaporate"?

11. Where does the water come from that forms dew? Why does it condense?

12. Look at page 97. How can you tell which way the wind blows? Why does the cloud banner form?

13. Examine the picture on page 98. Tell which side of the mountain has the heavier rainfall. Which is the

windward side of mountains (side facing the oncoming wind)? How can you tell from the picture?

14. Compare the picture at the top of page 99 with the picture at the bottom of the same page. In the upper picture what corresponds to the heat of the gas stove? to the water in the kettle? to the clear area at the spout of the kettle? to the cloud near the plate? to the cold plate?

IV. Think these out:

1. In Arizona many mountains have pine forests while the lower lands have only scattered desert plants. Why?

2. When a person who wears glasses goes out of the warm room on a cold winter day, why does not a fog form on his glasses?

3. After a sunny day, why does dew often form on grass but not on rocks?

4. In the morning you may sometimes see fog in the valley when the sun is shining on the hills. Why?

5. On cold, clear winter mornings you may find the windows of a warm room covered with frost. Is the frost on the inside or outside of the window? Why?

V. Word list. Suggestions:

evaporate	condense	water cycle
vapor	cycle	

Add also the words which you "picked up" as you read.



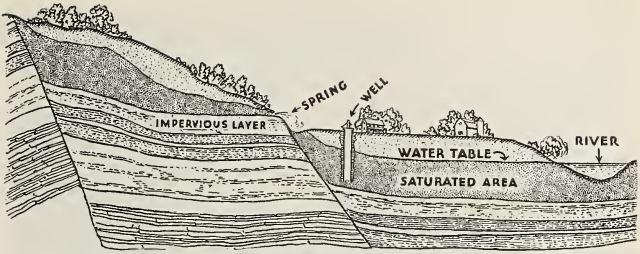
CHAPTER TEN

WATER ON THE EARTH

Springs. Did you ever try to find a spring? Where would you look, high on a hill or low down? Why? What makes a spring?

A spring is water flowing out of the ground. You might expect it to flow more freely from the bottom of a hill than from the top. Water flows downhill. But why does it not come out of the ground high on the hill instead of staying underground? Not every hill has a spring near the bottom. Some hills have springs up near the top, and some have no springs. There must be some reason why water comes out of the ground in some places but not in others. Can you find the reason?

You know that you can make a cup or bowl of clay and that it will hold water. Pottery is made of clay and baked. Clay does not let water through, or lets it through very slowly. If water flowing underground comes to a layer of clay, it cannot go through the clay. Now look at the picture. This represents the interior of a hill. When the rain falls on the top and sides of

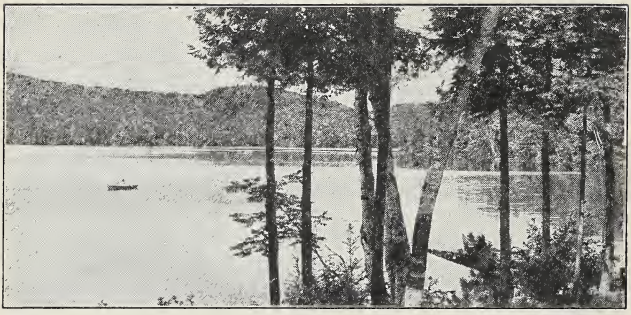


Tell why the water comes to the surface as a spring instead of sinking deeper into the earth. Why does water collect in the well? Is this river likely to dry up in summer?

a hill, some of the water sinks into the ground. Water in the ground flows downhill, just as it does on the surface. If it comes to a layer of clay or rock it cannot go through, it must flow downhill on top of the clay or rock. If the clay comes to the surface on the side of the hill, the water comes to the surface as a spring.

Streams and ponds. Water flowing down from the spring forms a brook. When it rains, water flows over the ground and swells the brook. Little streams flow to the lowest parts of their valleys, joining other streams as they go. A depression in the valley may be filled with water, forming a lake or pond. We make artificial lakes by building dams across valleys. Natural lakes form behind dams that are already in the valley. We shall see later that dams are often made across valleys when glaciers drop gravel and rock as they melt. The Great Lakes were formed by water flowing into great depressions.

If water keeps coming into a pond or lake, it must find a way out, provided there is water enough. In its journey to the sea, water may rest for awhile in a lake before continuing down the valley. On its downward journey it is joined by more water from other valleys, and by rain water running from the



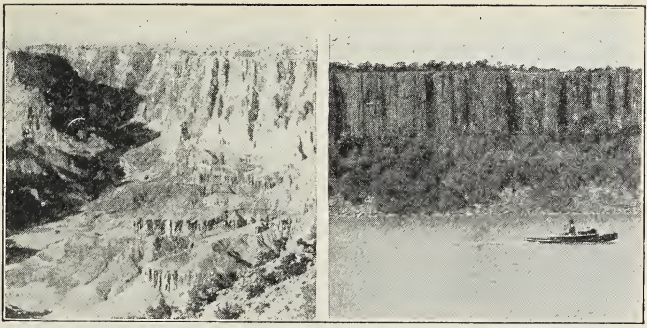
Philip D. Gendreau, N. Y.

A glacial moraine dammed a valley and caused this lake

land. As the stream gets larger, it possibly cuts down below the level of ground water and springs flow into it directly. If the depression that forms the lake is deep enough, springs will open under water. When you go swimming in lakes and ponds, you no doubt swim occasionally into the chilly water coming up from an underwater spring. Such spring-fed lakes are less likely to get as low in dry weather as lakes fed only by small streams. The springs help to *stabilize* the flow of the water in the streams. The size of the river depends upon the amount of rain, the breadth of its drainage area, and the length of the journey that the river must make before reaching its end in the sea. The mighty Mississippi drains much the larger part of the United States from the crest of the Allegheny Mountains to the crest of the Rockies.

The depth of a river depends not only upon the amount of water coming from above but also upon the depth of the valley. Thus the Hudson River is deep in its lower course because its valley is a deep trench extending below the level of the sea.

Water wears away land. You have seen muddy water flowing down a brook, after a rain. That mud



H. Armstrong Roberts, Phila. *Ewing Galloway, N. Y.*

The Canyon of the Colorado was dug by the river, and the Palisades of the Hudson are being carried away by the river

is the land taking a journey to the sea. The rain which falls on the hills flows down, and as it flows washes along anything small enough for it to carry. If you take up a tumblerful of the muddy water and let it stand in a glass until the next day, the mud will settle to the bottom of the glass. You have noticed the mud left on the walk where a muddy rill from bare ground flowed across it. On a larger scale you perhaps have seen flats of mud left along a creek or river when the muddy water withdrew after a flood.

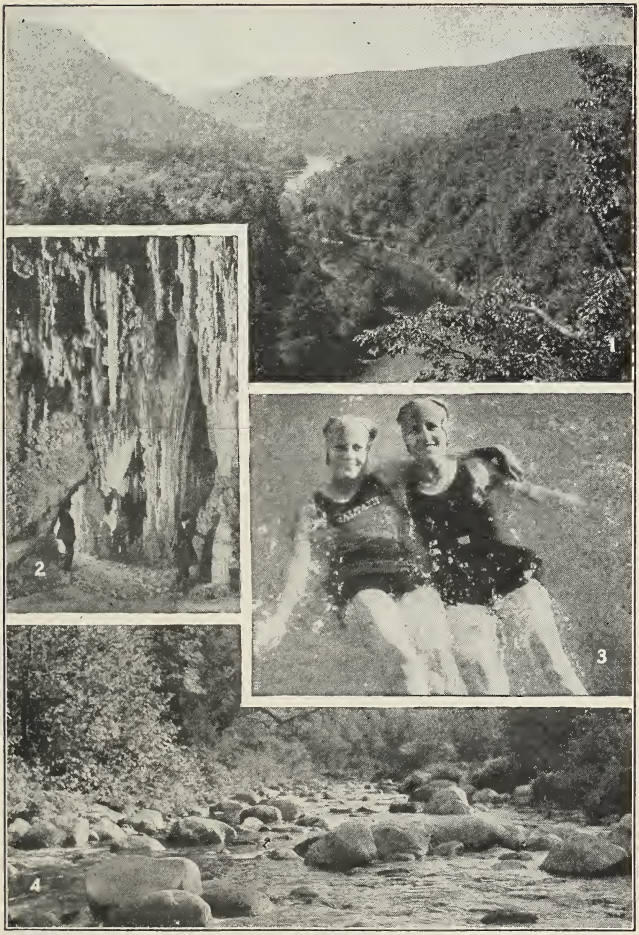
All that mud is hills washed away. If the process keeps up long enough, the hills will all be washed away. You may think that will take a long time. Well, nature has plenty of time. Geologists, the scientists who study the earth, tell us that in the history of the earth, whole mountain chains have been washed away. Look at the picture on this page of the Grand Canyon of the Colorado. That great gorge, a mile deep and fourteen miles across the top, was dug by water. It is estimated that it took somewhere between ten and fifty million years to wash away the rock to form that canyon. If you stand on a hilltop you may see

river valleys that were dug by water. Along every little brook you see how the land has been worn and carried away by water. The wearing away of land is called *erosion.*

The load carried by a stream. Have you waded in a creek and felt the swift current tumble the stones over your toes? Or have you felt the waves at the seashore drag pebbles or sand over your feet? The pebbles may be too heavy for the water to float as it does the mud, but it can roll them along. The swifter the water the larger the stone it can roll. Swift mountain creeks may roll cobblestones along their beds. When water comes down in a flood, the river rolls along much larger stones than when it flows along quietly. As the current slackens, the load of stones is gradually laid down, the bigger stones first, the pebbles next, the sand later and the mud last of all. You can see this happen in the glass jar of water that you stir up and then allow to settle. You can see that it has happened at the foot of a rapids.

In addition to the floating mud and rolling stones on the bottom, water carries minerals which have dissolved, as salt dissolves in water. If river water is heated in a pan until it all evaporates, the minerals are left behind. You might be interested to see how much mineral matter you drink in a glass of water. Boil away, gently, a glassful in a bright pan on the stove and see what remains. Water flowing underground in limestone countries dissolves away so much rock that great caves are formed.

The Mississippi River carries to the Gulf of Mexico each year four hundred million tons of floating mud and one hundred twenty million tons of dissolved minerals. That load would fill twenty-six million freight cars and make a train that would stretch ten times around the earth. That load tells us how fast



1. Publisher's Photo Service 2. Atchison, Topeka and Santa Fe Ry. 3. DeCou from Ewing Galloway 4. Philip D. Gendreau

1. Flowing for ages, this river has worn a deep valley. 2. A river wore its way through rock, forming a cave. The stalactites are made of minerals left by dripping water. 3. How did the salt which makes the bather float in Great Salt Lake get into the water? 4. Cobblestones are worn smooth and finally ground to sand by the action of running water.

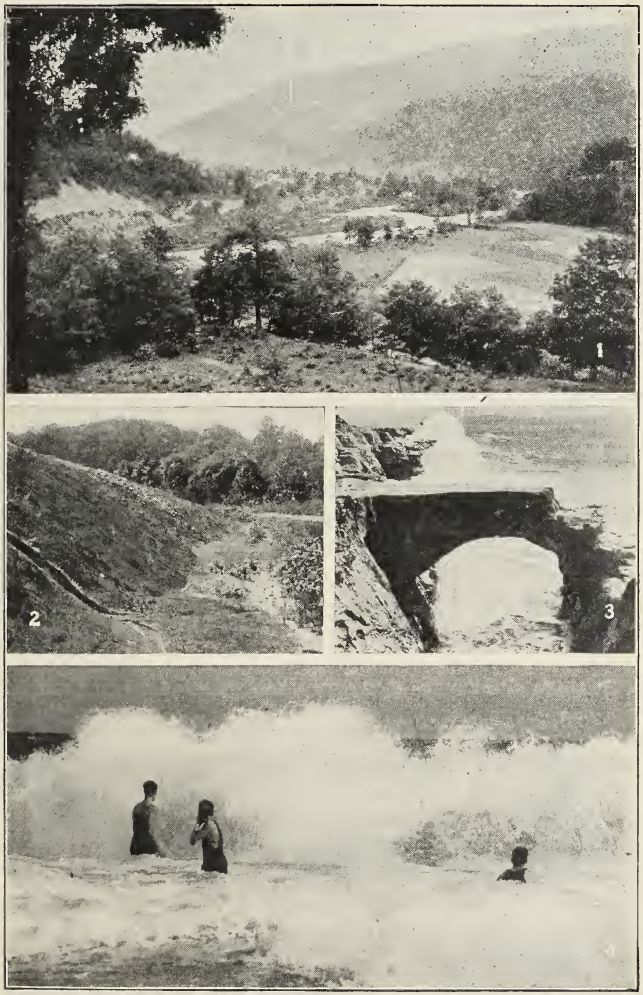
the central part of the United States is being carried into the sea by one river system.

Why the sea is salt. Water gets out of the sea only by evaporation, and in evaporating it leaves its salt and other minerals behind. That is why the sea is salt. For countless ages rivers have been flowing into the sea with dissolved salt and other minerals. For ages the salt has been left. The sea is getting more salt as the ages roll away. Great Salt Lake and the Dead Sea have gained so much salt that a person cannot sink in their waters. Many lakes in the West have so much other mineral matter in addition to salt that they are called *alkali* lakes. Their water is very bitter. Ocean water is bitter as well as salty, because other minerals are dissolved in it.

Water builds land. In addition to carrying away our soil, water is making more soil for us and spreading some of it out where we can use it. As the stones roll along the bottom of a creek they wear away their edges and the rock bottom, grinding the pieces into fine mud. Similarly, as water carries soil and bits of rock down hillsides it grinds it constantly finer. Along a creek or river you perhaps have seen level stretches that are sometimes covered by the water in flood. These stretches are called *bottoms* or *flood plains*. They are usually rich farm land. The farm lands of Egypt are the flood plains of the Nile. Along the Mississippi and its tributaries flood plains are also rich farm lands.

Water distributes the soil it carries. It distributes some to the flood plains and leaves more in the bottoms of streams and harbors. Dredges in our rivers and harbors are constantly digging away the silt, or fine mud, laid down by the rivers.

So water flowing down over the land is constantly wearing away the higher land and carrying it off. It



1. U. S. Forest Service. *3. Pictures, Inc., N. Y.* *4. Ewing Galloway, N. Y.*

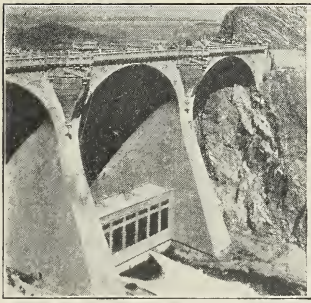
1. These flood plains are made rich by topsoil from the distant hills. 2. Study the picture of this gulley and tell how the earth's surface is changed by water. 3. Waves carved this natural bridge. 4. When one is hit by a breaker one realizes the force of water.

is constantly making new soil to replace that it has carried away, carrying this soil away in turn and spreading it out. Then it picks up the soil again and carries it on to sink it in the sea. Water is the constant enemy of the land.

Force of moving water. If you have been hit by a breaking wave, if you have stood under a small waterfall, or if you have waded against a strong current in a creek, you know that moving water has force. That force rolls stones and breaks down dams. When storm winds drive breakers ashore, the water tears away piers and houses and carries their battered timbers out to sea. Centuries ago man learned to harness the force of moving water and put it to work. Water wheels are ancient inventions. Today harnessed water power provides electricity to run trains, trolley cars, and factories, to light our cities and houses, and to do much of our household work. To get the force of falling water great dams are built across river valleys giving a greater fall at one place.

Saving the water supply. In the upper waters of streams, dams are built to make lakes or enlarge small lakes for water storage. During dry seasons this water is gradually released to maintain the flow of water at the power plants. Forests are protected at headwaters because forests hold water in the ground and allow it to flow out slowly from springs to supply the brooks and creeks that feed the main streams.

Forests, lakes, and reservoirs behind dams not only save water for dry seasons, but in addition reduce the danger of floods. When deluges of water come down the valleys, the streams overflow and cover the banks and surrounding country. Farm buildings, towns, dwellings, factories, railroads, and roads may be destroyed. Good farm lands may be ruined. Embankments or levees built along the stream banks are



Philip D. Gendreau, N. Y.
One way to change destructive power into useful power



Underwood and Underwood, N. Y.
Levees help to keep unruly rivers in check

used in many places to restrain high water. Often in floods the river breaks through the levees and floods the lower lands, driving out the people, drowning their stock, and destroying lands and buildings. State and national governments are planting forests on the hills in the upper courses of streams and building dams along the streams to hold back the water to prevent floods and to supply water in times of drought.

Things to Do in Learning about Water on the Earth

I. Read the chapter.

II. By observation and experiments, study water and erosion.

1. Field study. Visit a spring if you can. Take your notebook along and a bottle for a sample of spring water. Write in your notebook: (a) date; (b) the name or location of the spring; (c) its height: on the hilltop, near bottom, midway; (d) why the spring is there, if you can decide; (e) is the water clear or muddy? (f) cool or warm? (take its temperature if you can carry along a thermometer); (g) what becomes of the water? Fill your bottle with water for Experiment No. 10. Your study may be continued in No. 2.

2. Field study. A brook and pond or pool. If you cannot visit a brook at this time, you may be able to find

pictures in books, magazines, and newspapers for this study. If you can, cut them out and mount the pictures in your notebook with the report of this study.

(1) How does the brook start?

(2) Does it flow rapidly or smoothly? Why?

(3) Is its bed rocky, gravelly, sandy, or muddy? Why? You may be able to think out the reason for its bed.

(4) Are the banks steep or gently sloping? Why?

(5) Does it flow all the year round or does it become dry in the dry season? Why?

(6) Are there pools and ponds along its course? Why does the water collect in the pools?

(7) What kind of bottom has the pond? Why? Is the bottom the same as that of the brook? Is it the same where the brook enters the pond as where it leaves? Why?

(8) Collect some gravel stones or pebbles from the bottom of a swift brook and some stones from the foot of a cliff away from a stream. Are the pebbles similar in shape? Think out a reason for any difference that you find.

(9) Look for flood plains along brooks and rivers.

(10) Take some muddy water, pebbles, and sand to school or home for Experiment No. 11.

If you have a camera, take pictures of all the things you study in the field and paste them in your notebook, with proper titles.

3. Study the drainage area of streams from maps and in the field. Make a rapid sketch map of the United States and show the area drained by the Mississippi. Mark the divides that separate it from other drainage areas. Make a similar map of the drainage of the area in which you live. Make a little sketch map of the brook that you studied in the field and mark the divides—the heights which separate one brook valley from the next.

4. From a study of maps, locate lakes and decide why they are there. Pictures of smaller lakes often show why they are there. Try to find such pictures for your notebook. With each picture write a title and a statement telling how the picture shows the reason for the location

of the lake. If you have studied a lake or pond in the field, write a report telling the following: name or location of the pond; reason for its location, telling why you think so; a sketch map or a photograph.

5. Visit an artificial (man-made) lake or pond or study one in pictures or maps. Why was the spot chosen for the lake? How was it made into a lake? Was it on a hill, in a valley, or on a plain?

6. Study from pictures and in fields how water digs away land.

(1) Look for gulleys like that shown on page 109. Take pictures of them, make sketch maps or cut out pictures for your notebook. Be sure that you always add a title for the picture and tell what it illustrates.

(2) Perhaps you can visit places like those shown on pages 107 and 109.

(3) Stand on top of a hill or study pictures taken from a hilltop. Can you see any evidence (anything to show) that water has taken away land? Add pictures to your notebook.

7. Study how water builds land. Look for structures like that in Figure 2, page 109, or others built by water.

8. EXPERIMENT No. 10. Learn if there is any solid material in spring water by evaporating it to dryness in a clean, bright tin vessel. It is better to boil down a large quantity of water and then evaporate the last small quantity in a small dish. Write the report in the usual form.

9. EXPERIMENT No. 11. In a tall jar, put some muddy water, sand, and pebbles. Mix them up well by shaking. Then allow to stand until the water has cleared. It may take until the next day. Then examine the layers of material in the jar. What kind of material is on the bottom? next? next? Conclusions: State the order in which the materials settle? What makes them settle in that order? Write a report of the experiment in the usual form.

10. EXPERIMENT No. 12. Evaporate some sea water as you did in Experiment No. 10. You can make some imitation sea water by adding some salt, baking soda and other substances to water. Write a report of the experiment as in Experiment No. 10.

11. With a board, sand, and clay you might make a section of a hillside similar to that shown on page 103. Pour water gently near the top and see if you can form a spring. This requires some thought and patience.

III. Test yourself with the following questions:

1. Look on page 103 and explain how a spring is formed. Why does the underground water not continue under ground instead of coming to the surface at the spring?

2. Where do lakes form? Which lake is more likely to go dry in dry weather, a large shallow lake or a smaller deep lake? Why?

3. Where does the water come from that keeps rivers flowing in a dry season?

4. What evidence (facts) can you mention that shows that water wears away land?

5. In what order does water lay down the material that it carries along? Why?

6. In addition to the material from the land which you see carried in a stream, how else may streams carry away material? How can you show it?

7. Why is the sea salt?

8. When will water build land instead of wearing it away? Where would you expect to find such land?

9. How can you make water do work for you? What is gained by building dams across a stream?

10. What measures is the government taking to reduce floods?

IV. Think out these questions:

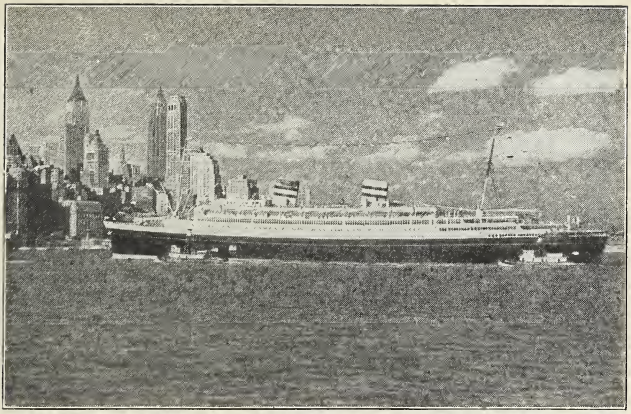
1. How deep would you need to dig a well to give water in dry weather?

2. Why is Great Salt Lake salt water and Lake Superior fresh water?

3. Suppose high up on a hill you found a great bed of gravel made up of rounded pebbles. What would you decide about the past history of that gravel?

V. Word list. Suggestions to add to your own list:

erosion stabilize artificial vocabulary



Underwood and Underwood, N. Y.

CHAPTER ELEVEN

THE VALUE OF WATER

Travel by water. Man makes many uses of nature's supply of water. Water transportation is the cheap transportation, and until the improvement of the airplane it was often the only transportation and means of travel in wild regions. Before the white settlers came to America, canoe trails carried the Indians through great forest areas. By winter dog sleds carried them over the frozen lakes and streams and through the snow-filled forests.

Before the great expansion of the railroads in the United States, rivers were the most important means of carrying freight long distances. It was cheaper to carry freight from Pittsburgh down the Ohio and then down the Mississippi to New Orleans for shipment to Europe than to take it by wagon over the mountains to Philadelphia, New York, and Baltimore. For this reason canals were dug to carry boats where the



The Indian valued the water



The New York Barge Canal is made up of four canal systems. Nearly half the State is within twenty miles of these waterways.

rivers were insufficient. Today most of the canals of the United States have been abandoned, although in recent years there has been a movement to again extend our inland water system. Commercial transportation is demanded from New York to Florida by the inland waterways. In Europe the canal and river systems have never been abandoned but are today important means of shipment.

Water determines location of cities. When the first settlers came to America, they had to find harbors to shelter their ships from storms. The first towns and cities grew up around these harbors, Boston, New York, and others along the Atlantic. The ships bearing the colonists sailed up rivers and bays that carried them into the interior. Along these rivers arose other cities, Philadelphia, Baltimore, and Quebec. As the pioneers pushed westward, the rivers offered the best routes of travel. At convenient points along the rivers other cities sprang up. Thus Pittsburgh arose at the junction of the Allegheny and the Monongahela rivers where they form the Ohio. St. Louis, below the mouth of the Missouri River, became a great center when settlers were sweeping westward in buffalo days. Sometimes water power along a river determined the location of the city, as

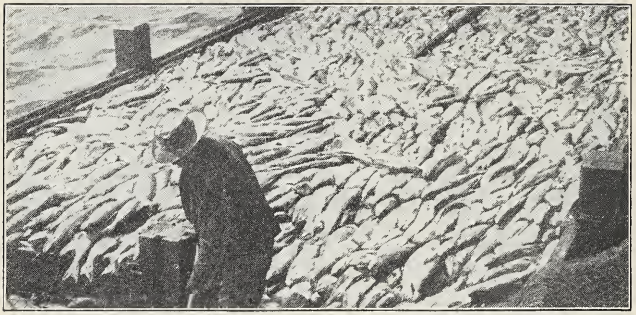


Underwood and Underwood, N. Y.

New York City largely owes its prominence to its splendid harbor and approaches to the rich country

at Minneapolis and St. Paul. On lake shores cities arose where there was shelter for boats or where river or overland trails met the lake. Thus arose Buffalo and Chicago. On the Pacific coast, similarly, cities arose, as Seattle and San Francisco. As the country behind the cities became settled, these cities that were so situated that the products of forest, mines, and farms could be most conveniently shipped through them and goods brought in, grew to be great centers. Thus New York and Chicago became the two largest cities in the United States.

Water supplies food. Streams fed early man and made important additions to the food supply of our early settlers in America. Great piles of mussel shells are still to be found along rivers where early people threw them after dinner. Accounts written in colonial days tell of wagonloads of fish taken from the rivers in the spring runs of fish. Along the Pacific coast today trainloads of salmon are still taken. In our eastern streams, however, little remains of the enormous migrations of fish up the streams that helped the colonial farmers and town dwellers. Shad are still taken in some streams and river herring in the streams near Chesapeake Bay and in southeastern



Underwood and Underwood, N. Y.

In spite of their vast number, the salmon supply is in danger

Massachusetts. Inland streams also furnished the pioneers with food. Today sewage and factory wastes make many streams unfit for fish. Where streams are not polluted, fish still furnish sport and recreation, but there are not now enough fish in them to appear in the markets. When we as a people are ready to stop the pollution of streams, we can again make the streams a source of food as well as sport.

The sea remains today a very important source of food. The United States produces over one hundred million dollars' worth of fishery products each year. Herring, cod, haddock, mackerel, salmon, sardines, halibut, shad, as well as oysters, clams, shrimp, crabs, lobsters, are some of the foods coming from the seas and salt-water bays. The North Sea has yielded vast quantities of herring and other fish for over a thousand years and still yields a billion herring a year.

Water gives recreation. Water sports of other kinds than fishing are equally valuable for our people. Recreation is as necessary as work to keep a healthy people. Boating and bathing are fine sports to keep men and women, boys and girls out in the sun and wind. Crowded lake and sea beaches, and in some



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The shores of lake or ocean offer recreation in the sun and wind

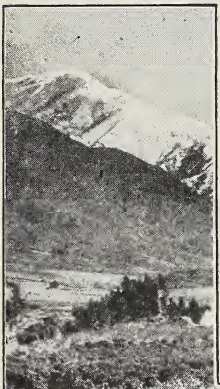
places the streams, show how people love water recreation. But we are damaging lakes and rivers and, in some places, the seashore with sewage and other wastes. This damage by pollution can be stopped, but it will cost some money to dispose of wastes in other ways than by destroying our water supplies. We can well afford to restore our streams, and the returns in food supply, recreation, and health will pay for the expense.

Value of location. The value of water depends upon where it is. The use man makes of water depends first of all upon where he finds it. In the sea, man uses it chiefly for transportation. Sailing the seas is much the cheapest way to get about the earth and to carry large burdens. The sea, also, is man's chief source of fish, as well as shellfish, sponges, pearls, and many other products. In the warm parts of the earth, the sea is the source of salt. Iodine, potash, and other chemical substances are also taken from the sea water. In addition, the seashore provides the most popular bathing places.

Nature makes other uses of the sea which determine man's activities. The sea is a never-exhausted source of moisture that supplies rain. The sea, too,

modifies the temperature of near-by regions. It is warmer in winter and cooler in summer by the sea than in the interior of the United States.

When abundant water is found in the mountains, it is very valuable. It may be led away to supply cities or to farms for irrigation. It may lead to a power plant, or the power plant may be located in the mountains and electricity led away. The area from which a water supply comes is called the *watershed.* Mountains are exceedingly valuable as watersheds. Forests and lakes in the watershed are protected to save the water supply.



When plains and valleys are supplied with water, they are the farm lands. The coastal plains, the lake plains, the prairies, and the Great Plains where there is sufficient water supply food not only for our own population but produce abundant supplies for export to other countries.



Ewing Galloway, N. Y.

Mountain streams, when properly directed by man, turn the desert into a garden. Here is shown an orange grove

Even water in the high mountains far from civilization is valuable. The far-distant watershed may supply great rivers that travel hundreds of miles before they pass through land that can be used as farms or as town sites. Great rivers flowing from the distant mountains of the West furnish the water for the lands and cities on their lower courses. The waters of the Nile that change the desert into the fertile land of Egypt come from the distant mountains of Abyssinia and Central Africa.

Things to Do in Learning about the Value of Water

I. Read the chapter.

II. By observation and thought, study the value of water.

1. Did you ever take a "map journey"? Get out a map of the United States and plan a water journey from New York to New Orleans. Plan another through your own State. Turn to the northwest region of Canada. Follow the routes of travel before airplanes were invented. The airplanes used in this region are equipped to alight on water. Trace possible airplane routes.

2. With a map of the United States count the number of important cities that are on rivers, lakes, or seas and the number that are not so located. What conclusion do you draw? What reason could have led to the founding of cities on water?

3. Look over the shelves at the grocery store or the advertisements of food. List the foods that come from fresh water and those that come from the sea.

4. Visit the streams big and little. Are they contaminated? by what? Does your State have laws to protect streams from contamination?

5. Learn whether your city and State provide for the use of water for recreation of its people. Locate recreation areas that make use of water.

6. Write a list of all the ways in which water benefits man.

7. England was much concerned when the Italians set out to conquer Ethiopia. Turn to a map of Africa and see if you can find a reason.

III. Test yourself with the following questions:

1. How many ways does man make use of water? (They are not all mentioned in this chapter.)
2. Why does man use water transportation?
3. Account for the location of New York, Minneapolis, New Orleans, San Francisco, your own town or the big city nearest you.
4. What did early man get from the streams? What do we get today?
5. How does man benefit indirectly from the sea and other waters?
6. Study maps and tell how your region and selected other regions benefit by water from hundreds or thousands of miles away.
7. Go back to the introduction of Unit IV and answer the questions raised there.

IV. Think these out:

1. Is water transportation nowadays greater or less than a hundred years ago? Be ready to argue about it, showing the reasons for your answer.
2. Certain canals of the United States were kept in condition when most canals were abandoned. Tell why these canals were maintained for use.
3. Compare the uses of water today with the uses of former times. Are we making greater or less use. (That is a big question.) What uses? Why the change?

V. Vocabulary. Suggestions for you list:

watershed recreation



UNIT V

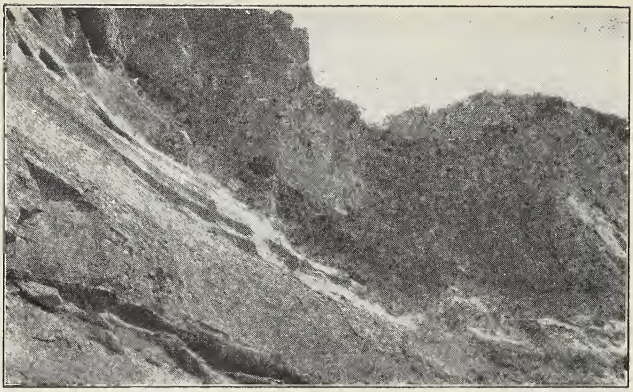
ROCKS AND SOIL

HOW are rocks made? Perhaps you thought they were always here. Some of them have been here a long, long time, but others have been where you see them only a short time as the scientist measures the history of the earth. By studying the make-up of rocks the scientist comes to a conclusion as to how and where they originated. Some rocks three miles high were once under the sea. Have you noticed rocks folded like the sections of a jelly roll? That tells a story to the scientist.

You know very well, if you have seen a cliff, that rocks crumble and weather away. When things happen, there is always a reason why. You might guess that the great glaciers that covered the northern part of the United States once upon a time, ice a mile thick, might wear away some rock. But you might not guess that the air, the ants, the bacteria in the ground, the tiny plants that you see sticking to the rocks, are perhaps mightier than the great ice sheet because they are ever at the work of destruction.

Was the soil always here? It comes and goes as the rocks do. Whence does it come, and whither does it go?

Nothing is more precious to you than the soil. Were it all to go, you would starve. Yet as a people we are very wasteful of the soil. Many farmers waste their soil, but others save it as the miser saves his gold. Why does the farmer drag his various implements across the fields? Well, among other things, he is making the soil right for the bacteria to grow in, for they are among his most valuable crops.



Ewing Galloway, N. Y.

CHAPTER TWELVE

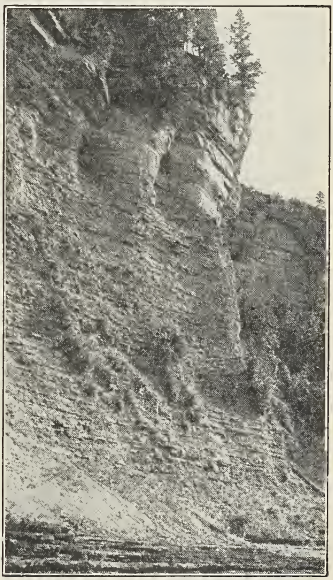
HOW ROCKS ARE MADE AND USED

Soil becomes rock. When the Mississippi and other rivers wash the soil out to sea, it spreads out and settles to the bottom. Layer after layer is laid down, all assorted in sizes. You saw how the water sorted the material when you put a handful of mixed gravel, stones, sand, and mud in a jar of water and shook them around. When you allowed the water to stand, you found the soil arranged in layers with the bigger stones in the bottom and the fine mud that settles last on top. So soil carried out to sea has settled. Thousands of feet of sand and mud have been spread one layer on top of another.

Farther out to sea other materials have been spread over the sea bottom, layer after layer. When shellfish and other sea animals die, their shells and skeletons sink to the bottom. Microscopic animals live floating in the sea in vast quantities. As these animals die, their skeletons drift slowly down to the bottom of the sea. Many of the shells and skeletons are lime. Thus great layers of lime are laid down on the sea bottom.

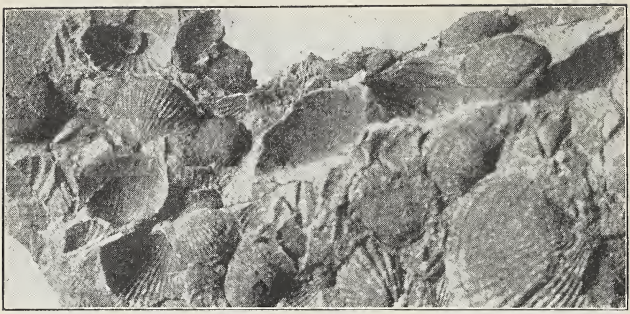
As the centuries roll away, the layers of sand, mud, and lime grow to great thickness. These great layers are heavy. The lower layers are pressed under great weights. Water soaks through the layers. In the water are many substances in solution. Among them are iron and lime substances. You have probably seen an old hinge so rusted that it will no longer work, the parts cemented together by iron rust. You have also seen mortar and concrete in which sand and stones are cemented together by lime and other substances. In the great beds of sand, clay, and lime under the sea the tiny particles similarly become cemented together. The great pressure of the material above helps to make the cemented mass hard. The material becomes rock.

We can easily recognize those rocks that were once under the water. We can sometimes see the sand grains and the gravel stones in the rock. The rocks lie in layers just as the sand, mud, and lime lay in layers under the sea. The layers are called *strata*, a Latin word which means "layers," and the rock is called *stratified* rock. It is also called *sedimentary* rock because the material which settles in water is called *sediment* from a Latin word which means "settle."



Philip D. Gendreau, N. Y.

Strata of rocks in the face of a cliff. Broken particles have slid down to the base and are becoming soil.



Hugh Spencer, Chester, Conn.

Fossil shells imbedded in hardened mud

You can easily recognize sedimentary rock when you see it where a stream or a road has cut through a hill. Next time you look upon such rock, just stop a moment to think that it was once under the sea even though now it is two thousand feet high in the mountains.

Kinds of sedimentary rock. There are several kinds of sedimentary rocks that you can easily learn to recognize. Sand becomes sandstone. With a good lens or magnifying glass you may see the grains of sand. The little particles often have a glassy appearance like sand on the beach. The rock feels gritty when you scratch it with a knife. Its color is often red, brown, or yellow, or it may be white like sea sand.

The clay and mud become *shale.* As mud and clay are made up of fine particles, shale is fine grained. If you breathe upon it, your mouth opened, it often smells like clay or mud. It easily breaks into thin layers and crumbles away from the cliff. It varies in color from red, brown, to gray and black. Shale is usually soft and easily scratched with a knife.

The lime of the sea bottom becomes *limestone.* You can easily recognize limestone after you have

once learned to know it. It is soft, easily scratched with a knife. If you breathe upon it, it has an odor that you will remember. If you put a drop of acid on it, it foams and bubbles. This foaming is due to the formation of a gas, carbon dioxide, which is escaping. Limestone may be gray, blue, or white.

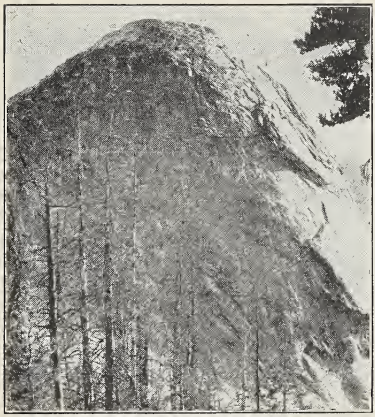
Dead remains in the rocks. When dead animals, shells, and skeletons are buried in the mud and sand of the sea bottom, the water gradually dissolves away most or all substances of the body, shell, or skeleton, but in their places deposits other substances which were in solution in the water. Thus the form of the shell or skeleton is preserved. Such remains of ancient plants and animals are called *fossils.*

Now we often find fossils of shells, salt water fishes, and other sea animals in the rocks of dry land, sometimes in rocks high in the mountains. We conclude that those rocks were once sand, mud, or lime under the sea. Since those ancient days the rocks have risen out of the sea and become high mountains.

Folded rock. You may often see layers of rock that are no longer level. They may be tilted to one side or folded. Mud and sand cannot settle that way under the sea. They settled in flat layers. However, as the land rose out of the sea and was pushed up into mountains, the layers of rock were tilted and folded. Sometimes the rock became very hot in the folding of mountain making just as a piece of tin becomes warm if you fold it backward and forward many times. The



Folded rocks



Philip D. Gendreau, N. Y.

This solid granite mountain peak is the core of the mountain from which softer rock has been eroded away

great pressure also made it hot just as the bottom of a pump gets hot from pressure when you pump air into your bicycle or automobile tire. If the heat and pressure are great enough the rock changes in appearance, and becomes much harder. Limestone becomes marble, shale becomes slate, and sandstone becomes quartzite. [Such changed rocks are called *metamorphic* rocks from Greek words which mean "changed form."]

Fire rocks. Sometimes, also, in mountain-making the rock splits apart, and molten rock comes up from the interior of the earth. The molten rock may reach the surface and flow out on top, or it may spread out between the layers of sedimentary rock. Then it slowly cools and hardens, also into rock. Such rock that was once molten is called *igneous* rock from the Latin word which means "fire."

From volcanoes an igneous rock flows over the ground and hardens. This rock is called *lava.* In the heart of the mountains or of hills that are the worn-down remains of mountains you may see another kind of igneous rock. Sometimes the molten rock cools slowly deep down under great layers of sedimentary rock and forms *granite.*

If you examine carefully a piece of granite you will easily see that it is not all one substance but is made

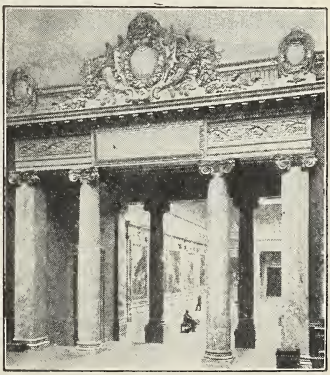


University of Pennsylvania Museum

Stone was the material from which ancient man made his implements

up of three distinct kinds of substances. These are three different minerals. There is a dark mineral in thin scales. This one is *mica*. A white glassy one is *quartz*. A white or pink, glistening one, not so glassy as quartz, is *feldspar*.

How man uses rock. Man learned to use stone before he learned to use iron. He chipped out axes, knives, scrapers, and arrowheads in the Stone Age. Later he learned to build himself a house of stone. He still builds stone houses. Sandstone, brown or gray, makes a beautiful house. Some sandstones, however, crumble away on the surface when exposed to the weather. Limestone is often more beautiful, and usually lasts well, but sometimes acid smoke from certain industrial plants disfigures it and makes the surface crumble. Marble is a beautiful stone sometimes used in costly buildings, and for monuments. Many beautiful marbles are used for interiors of buildings. Other stones, too, are used in house building, for man must use what he finds at hand or pay the expense of transporting or manufac-



Underwood & Underwood, N. Y.

Because of its beauty and variety marble is much used in buildings

turing substitutes. Granite is hard and resistant to the weather. It is a beautiful stone, especially when polished. It is used for building, for monuments, and because of its hardness, is used for paving. Sandstone and some other stones are used also for grindstones and whetstones. Slate is used for blackboards and roofing.

From rocks, also, we get our metals. Iron, copper, aluminum, lead, tin, and other metals are found in compounds mixed with rock. These rocks are called *ores*. Iron is obtained from its ore by mixing the ore with limestone and coke and heating in a blast furnace. Lime is obtained by burning limestone. Cement is obtained from certain kinds of limestone. Glass is made from sand, and pottery from clay.

Things to Do in Learning How Rocks Are Made and Used

I. Read the chapter.

II. Study by observation and experiment how rocks are made.

1. Turn back to Experiment No. 12 and tell what you learned in that experiment.

2. Look at pictures on pages 124 and 125 and look for similar formations in gravel pits, railroad cuts, road cuts, steep banks of streams, and cliffs. If you cannot go to the field, go to the library and search for similar pictures. If you have old magazines at home search them for similar pictures to paste in your notebook.

3. Experiment No. 13. Man-made rock. Mix one fourth glass of dry cement and one half glass of sand in an old tin can. Wet some pebbles and mix them with the sand and cement, meanwhile pouring in water slowly until a thick mush is formed. Pour the mixture into a paper box and allow it to harden for two or three days, wetting the surface of the concrete each day. When the cement is hard, remove the paper box. Write a report of the experiment in the usual form.

4. After you have studied the description of the sedimentary rocks, search for them in the field and quarries. Label them and add them to the school museum. Or take those provided in the laboratory and learn the names. Draw up a table describing the rocks.

Kind of Rock	Sandstone	Limestone	Shale	Granite
Color				
Smooth or granular				
Glassy or dull				
Hard or soft (test with knife)				
Odor				
Does water soak in				
Reaction to drop of acid				

5. Search for fossils in rocks at the foot of cliffs, in gravel banks, in quarries. If you cannot go afield, go to the library. Obtain pictures, and paste them in your notebook.

6. Search in the field for folded rocks. Look for pictures that you may use in your notebook.

7. Study a piece of granite to recognize the three minerals of which it is composed: quartz, feldspar, and mica.

8. Try to make a stone axhead as the men of the Old Stone Age did by chipping away one stone with another.

9. Study the stone in buildings of your neighborhood. Write a report stating the location of the building, kinds of stone used, the particular use made of each kind of stone (foundations, walls, ornamentation). Is the stone resisting the weather or is it wearing away on edges and in cracks? Find other uses of stone and write a report on their use.

10. Try by Experiment No. 14 to extract a metal from the ore. Heat some red oxide of mercury in a test tube.

Mercury, or quicksilver, is easily obtained. Write a report of the experiment in the usual form.

III. Test yourself with the following questions:

1. How can you show that water sorts rock and rock materials into different grades?

2. How can you tell that rocks now high in the mountains were formed below the sea?

3. What makes the particles of sand stick together to form rock?

4. Why are some kinds of rocks arranged in layers? What name is given to these kinds of rock.

5. How do the remains of plants and animals get into solid rock? What is the name for such remains?

6. Why are certain kinds of rocks found in folded layers? Select pictures which show such rocks.

7. How are certain rocks changed when the layers of rock are folded and pressed?

8. Set up a row of different kinds of rocks and name each. Point out the minerals that compose granite.

9. Set out specimens of the kinds of stone that is used in buildings. Tell how each kind is used.

10. Tell one process by which metal is obtained from rocks.

IV. Think these out:

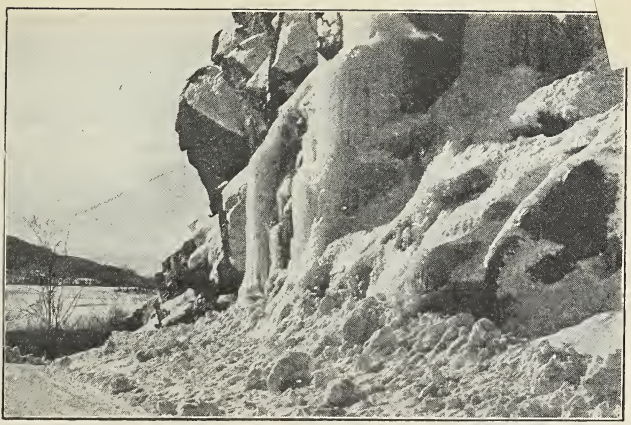
1. Why does not granite occur in strata?

2. If you found slate making up a part of a hill, what two facts would you decide about its history?

3. Could there be folded rock layers as on page 127 in a level area? Explain.

V. Vocabulary. The following words are suggested for your word list. Remember to add your own. No one but you knows what words are new to you.

strata	igneous	limestone
stratified	fossils	granite
sedimentary	lava	mica
metamorphic	shale	quartz
	feldspar	



Philip D. Gendreau, N. Y.

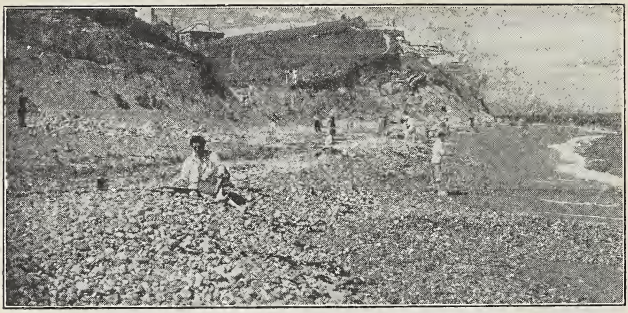
CHAPTER THIRTEEN

HOW SOILS ARE MADE

How rocks weather away. Did you ever fill a bottle with water to the very tip, cork it, and allow it to stand out on a freezing night or pack it in salt and ice? Next morning the bottle is broken. Water expands as it freezes. Perhaps on a cold morning when you brought in the milk bottle you have found a column of frozen milk an inch or more high standing in the mouth of the bottle. The water in the milk in freezing expanded and forced the column of ice out of the bottle.

Similarly, water that has seeped into the cracks of the rocks freezes, expands, and breaks off pieces of the rock, as it breaks a bottle. High in the mountains where frosts are severe even on summer nights, rock is rapidly broken to pieces. Such wearing away of rock is called *weathering.* Rain also brings about weathering by loosening rocks embedded in soil.

The loosened rocks roll down the steep slopes, breaking and grinding as they roll. At the foot of a cliff is usually a pile of loosened rock that once was

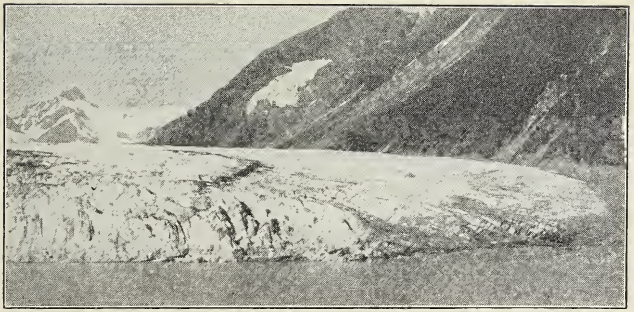


Douglas from Philip D. Gendreau, N. Y.

Waves rolling these stones against one another have made them smooth and rounded. Eventually they will be ground to sand.

part of the solid cliff. As you drive along roads cut in the hills, you sometimes see rocks that have rolled out from the sides of the cut. The little rivulets formed by the rain help roll the rocks along until they reach a stream. The swift currents of creeks and rivers roll them, grinding them ever smaller, grinding off the rough edges and rounding them into cobblestones and "river biscuits," pebbles, and gravel stones. On rocky beaches you can often hear the rocks roll and grind as the waves go back. When you find a bed of gravel on your hike, you know that it once was rolled around below water in a river, a lake, or on a sea beach. If the grinding continues long enough, the rocky stuff is made into sand and finally mud.

How glaciers destroy rocks. In high mountains more snow may fall in winter than can melt in summer. The great pile of snow is heavy. The snow underneath is under great pressure. When you press snow hard and constantly in your hands, it partially changes to ice. In the mountain snow field the snow changes to ice under pressure. In addition, when the sun melts the ice on top, the water seeps down into



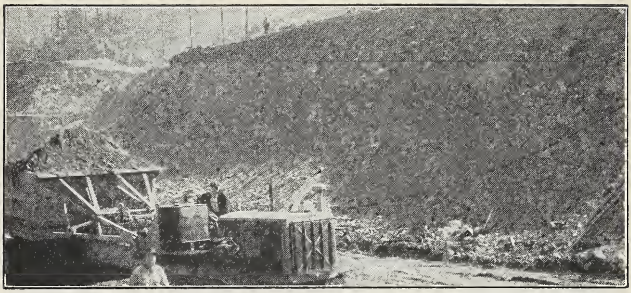
H. Armstrong Roberts, Phila.

The stream flowing from beneath the glacier carries a load of finely ground rock

the snow or flows into a crack and freezes. The snow gradually becomes ice. The great, heavy mass of ice moves slowly, very slowly, sometimes a foot a year, down the mountain slopes and valleys. This moving ice from the snow field is a *glacier.* The great weight of the ice with the rocks and stones frozen in the bottom of the glacier grinds away the solid rock beneath. Age-old glacial scratches on rocks are plainly seen. Some of the rock is ground into a whitish flourlike powder. The stream that flows from the end of a glacier is milky in color from this rock flour.

The great glacier changed rocks and soil. Some thousands of years ago great glaciers covered the northern half of the continents of North America and of Europe and Asia. Such a great glacier is called a *continental* glacier. In America the continental glacier covered Canada and the northern part of the United States. Greenland and the Antarctic Continent today are covered with such continental glaciers.

The great glacier moving for thousands of years scoured the soil away and ground off the rocks. Stones frozen in the bottom of the ice cut grooves in



Philip D. Gendreau, N. Y.

A cutting through glacial drift. Compare the earth with the water-laid earth on page 124.

the rocks below. Rock surface grooved with parallel scratches are found in the country once covered by the glacier, or ice sheet.

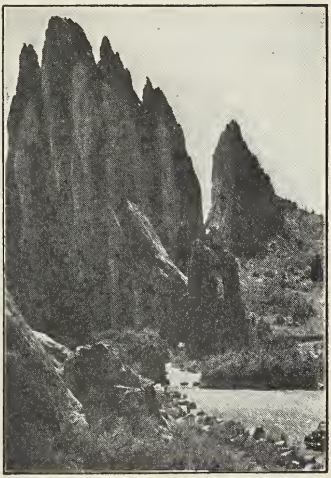
The soil and broken rock was pushed and carried southward. Boulders of Canadian rocks are found today in the Northern States. As the ice melted at its southern edge, broken rock and boulders mixed with sand, soil, and clay were dropped in a mixed mass. One can tell glacial material from material carried by water because water sorts out the material, leaving coarse rocks and gravel in one place, sand farther along and mud still farther out where the current was slow or the water was still. The glacier mixes all the material together; water sorts it according to sizes. The glacial material scattered over the country is called *glacial drift.* It is often piled up in banks and low hills called *moraines.*

Glacial drift makes up the coarse soil of New England and other parts of the Northern States. Sometimes we find long, low hills where the glacier left the stuff it carried to its end. Such a hill is called a *terminal* (end) *moraine.* Often the glacial material formed dams which blocked valleys and caused the

formation of lakes. The glaciated country of Canada and United States is dotted with such lakes.

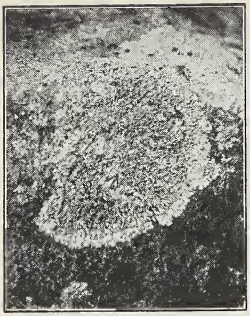
Where the water flowed out from the end of the great glacier it carried with it glacial drift. Great beds of gravel mark the course of the old glacial streams. The finely ground rock, glacial flour, was also carried out and spread upon the land. This type of glacial soil in many places has become very fertile. So the glacial soil in one place may be barren because of the coarse gravel and boulders. In another place where the glacial rock flour was spread out, a fine soil was laid down and has since become fertile in ways which we shall study presently.

Wind wears rock. One night on the beach in North Carolina an automobile was stuck in the sand during a blow and could not be moved. In the morning, the paint had been ground away and the metal body was clean and shining. Windows in lighthouses have been so badly ground during a single storm that they had to be replaced. Perhaps you have seen men using a sandblast to clean the face of a dingy stone building. Sand driven by compressed air grinds away the surface of the stone. So in the desert countries a natural sandblast grinds away the surface of the rock. Where the soil is not covered with plants the wind picks up the sand



H. Armstrong Roberts, Phila.

These rocks were hewn by the wind's sandblast



Hugh Spencer, Chester, Conn.

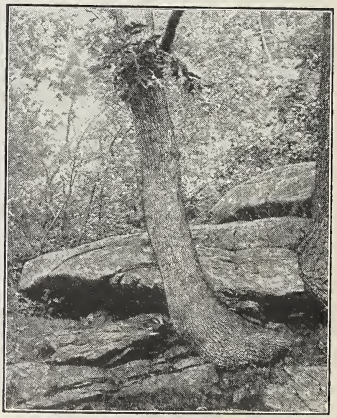
Lichens dissolve stone

and dust and drives them along against the solid rock, slowly grinding it away.

Plants and animals wear away rocks. On rocks you often see plants called *lichens* (pronounced lī′kĕn). Some of them seem as thin and as tight as a coat of paint. Others are tough and leathery. Many kinds of lichens seem to need no soil to grow in. Growing on the bare rocks, lichens slowly dissolve some parts of the rock. The rock crumbles a little and produces a little soil. Then other plants can start to grow. The more plants grow, the more is the rock dissolved away and the more soil produced. The roots grow into the cracks of the rocks, and as they thicken, force apart the loosened rock. Sometimes you see sidewalks raised and rocks split apart by trees growing in crevices.

Animals also help in the process of breaking up rocks into soil. The burrows of ground squirrels and woodchucks and even the tunnels of insects, let in the rain water and the air, which aid in crumbling the rock. Earthworms burrowing also turn over the soil, exposing fresh soil to the air, the wind, the rain, and the sun.

By all these forces, the solid rocks, and the huge



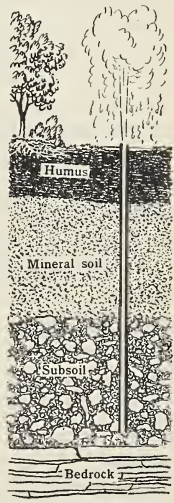
Hugh Spencer, Chester, Conn.

Trees often split large rocks

mountains, are being slowly, infinitely slowly—but certainly—changed into soil. Frost and ice, water tumbling along or slowly seeping in, air and sunshine, plants and animals, are the enemies of rocks and mountains, and the friends of all things that need the soil to support their lives.

Bed rock to soil. If you find a road cut, a cliff, or a hole dug by a steam shovel, you may see the stages in soil-making from the solid rock to the fine soil on top. At the surface there is a growth of plants, then a dark layer tangled with roots, then a lighter-colored soil, below this a much coarser soil mixed with broken pieces of rock increasing in size as you go down to the solid rock.

The dark layer at the top is colored by dead and decaying leaves and wood. This layer of decaying matter is called *humus.* Sometimes in the prairies and in the bog soil the humus may be many feet thick. In a hill country or in sandy soil there may be scarcely any humus. The humus layer is also called the *organic layer.* Matter that is alive or was once alive is called *organic* matter. As we shall see, this layer contains many living things. Living things are called *organisms.*



The layers of the earth

The lighter-colored soil below the humus is *mineral soil.* It contains little decaying matter and fewer roots. The coarse soil with the pieces of rock is the *subsoil.* It may be many feet thick or in rocky hills it may be only a few inches of rotted rock. The solid rock at the bottom is *bed rock.* In high mountains bed rock is at the surface. In valleys and plains the bed rock

may be buried so deep that it can be reached only by deep wells drilled through the overlying layers of soil.

Things to Do in Studying How Soils Are Made

I. Read the chapter.

II. Study in field and laboratory how soil is made.

1. Experiment No. 15. Will freezing water break rocks? Fill a bottle with water to the top. Force in the cork and tie it in with string. It may be necessary to slip in a straight wire along the side of the cork and to withdraw the wire when the cork is in. This operation is to allow the air to escape. Pack the bottle in a mixture of salt and ice. Report in the usual form. How does this experiment aid in understanding the weathering of rocks?

2. Go into the fields and search for cliffs or rock ledges that show weathering. Bring pieces to illustrate. Label properly, and add to the school museum.

3. Turn back to your field and laboratory studies of brooks and creeks and refresh your memory on how water wears away rock.

4. If you live in a country where moraines may be seen, go out and study them. What kinds of materials make up the moraines?

5. Gather pictures to illustrate the processes explained in this chapter and paste them in your notebook.

6. In the field search for lichens on rocks. Bring a specimen to school. Examine the rocks for evidence that lichens and other plants are causing any wear.

7. Experiment No. 16. Study the effect of earthworms on soil. Gather a few worms and some of the soil in which you find them. Place in a glass jar. After the worms have settled, cover the top of the soil with fine sawdust. The soil should be kept only slightly damp but not wet. In the evening, place small pieces of lettuce leaves on the soil. Look for evidence that the worms have used the lettuce. It is necessary to add other food. Pour just a little bit of milk occasionally on the soil. Sprinkle a little cornmeal on the surface. Examine the top of the soil for evidence that the worms are bringing soil to the surface.

8. Locate pictures which you think show that hills are worn away, and find evidence of such wear on your hikes. Take your camera along and take pictures to show the class and add to the science museum.

9. Look in a railroad or road cut or where a stream has cut away a bank for the stages from hard rock to topsoil. Pictures may sometimes be found to illustrate this.

Collect specimens from each layer and bring to school. Make a report of your trip to your classmates who did not go with you. Exhibit the soil and rock collection in bottles or glasses or even in boxes or paper bags. In suitable bottles, properly labelled, the specimens make valuable additions to the science museum.

III. Test yourself with the following questions:

1. What process in nature is illustrated by the experiment with the freezing bottle of water?
2. How can you recognize stones that have been worn away by water?
3. What does a glacier do to land?
4. How does a glacier make soil?
5. Explain how the rocks on page 137 were worn away.
6. How can living things wear away rocks?
7. Tell how you can recognize humus.
8. Quickly draw a diagram showing the layers of rock and soil from the solid rock to the top of the soil.

IV. Think these out:

1. How can the scientist tell that the northern part of North America was covered at one time by a glacier?
2. How could you tell soil made by wind from soil made by water?
3. How does man aid in the making of soil from solid rock?
4. Why is bed rock often deep below the surface of the soil in valleys but right on the surface on the mountain?

V. Vocabulary.

weathering	lichen	organism
moraine	humus	subsoil
erosion	organic	bed rock



Ewing Galloway, N. Y.

CHAPTER FOURTEEN

USING THE SOILS

How to get acquainted with dirt. You have probably dabbled more or less with dirt all your life so far, and have never looked at it to see what it is. It takes a course in science to find out what dirt is. Let us be dirt farmers for a little and dirt scientists. Gather a few handfuls of dirt here and there. Take a handful from the garden, another from the woods, another from a sandy beach or bar above the water level in a creek, and another from a clay bank. Get several pieces of white paper on which to spread out the soil for examination. Get a lens or magnifying glass and several glasses of water. Also you will need a gas burner and a piece of sheet iron or iron plate or something else in which you can heat the soil very hot. Get several small flowerpots or substitutes for pots; also get several test tubes and material for bacterial cultures. (Bacterial cultures are growths of bacteria in foods prepared for them.)

How water grades soil. Let us begin with the glasses of water. Drop a little of each kind of soil into

a glass of water, stir the water a little, and then let it settle. The water becomes muddy. The biggest-sized bits of soil settle quickly. Some stuff floats on top of the water. Let the glasses stand until next day. By that time the mud has settled and the water is clear. On top may still float some material. This floating material is made up of bits of dead leaves, of twigs, perhaps a dead ant or the wing of a bee. It is chiefly organic material (material that was once alive).

Soil that burns. Next use the iron plate. Put some of each kind of soil in turn on it. Heat it red hot until the soil smokes, and changes color. Something burns away. That is the organic part of the soil. You can form a rough estimate which soil had the most organic matter.

Things alive in soil. In each flowerpot put one kind of soil. Water and tend the pots of soil for a week or two as you would potted plants. See if any plants grow from the soil.

Make up some sterile beef broth to grow bacteria. (See Experiment No. 17.) (*Sterile* means "free of living germs.") Taking precautions to prevent contamination (entrance of germs from outside), drop some of each kind of soil and some of the broth into each of several test tubes and set them away for two or three days. Record the result in Experiment No. 17.

From these studies of the soil you may conclude that there are many dead and living things in the soil. As you dug around in the soil, you perhaps came upon many other things, worms, beetle grubs, and other insects, molds and white threads of other fungi. From your study with the test tubes you might conclude that bacteria swarm in the soil. If you could recognize them you might also find yeasts. There are microscopic animals, too, composed of only one cell each, and many other tiny animals almost as small.

Bits of rock. Now with the lens examine the portions of soil spread out thin on the pieces of white paper. You find angular bits with sharp corners and bits with rounded corners. They are like tiny bits of rock. From your studies in the last chapter you will conclude that the soil is worn-down bits of rock. The soil particles are not all the same size. Some specimens are composed of particles that you can see with the naked eye, and others of particles that can hardly be seen with the lens. When you rub it between your fingers, some soil feels gritty and some feels smooth and slippery.

Various soils. Soil is certainly varied and it is not simply dirt. It starts as solid rock, but it is not simply ground-up rock. To the rock particles have been added many bits of dead things, both plant and animal. They are in various stages of decay. In addition, there is a whole world of living things in the soil. Little wonder that some farmers make comfortable fortunes and other cannot make a living. Much depends upon the kinds of soil on the farm and what the farmer does with the soil. Knowing about soils is a large part of the farmer's education. Soils may be improved by cultivation (tillage, preparation for crops) or they may be ruined. The farmer must know his soil and know what to do with it.

Clay soil. If you ever got clay mud on your Sunday clothes you know what a mess it makes. It is sticky, and when it dries it sticks like hard glue. That is just the way it acts when the farmer tries to cultivate it and grow plants in it. When it is wet, it sticks to the plow, to the horses' feet, and to his own feet until they are so heavy he can hardly lift them. In fact, when it is wet a farmer knows clay soil is too heavy to work. He does something else until the soil dries out. But in dry weather, it is just as bad to

work. It bakes hard as bricks and opens in great cracks. The roots can force their way through only with difficulty. The great cracks allow the soil water to come to the surface and escape into the air so that plants lose the moisture they need.



Hugh Spencer, Chester, Conn.

Soil, greatly magnified

Clay holds water so long in the spring that it is slow to warm. Plants cannot grow until the soil warms. Therefore, clay soil is poor soil for early vegetables. It holds them back. Water is necessary for plants, but they cannot grow in water-logged soils.

Clay soil is very fine grained. Its particles are so fine that you cannot feel grit as you rub it between your fingers. With a little moisture it feels slippery. It takes up water very slowly, as you know if you have tried to work up some clay for modeling. When wet, however, it holds its moisture, drying out very slowly. That is the reason you can model it and make pots and bricks of it.

Clay soil is not the best kind for the farmer, but if properly cared for it has its good points. It does not dry out rapidly. The farmer can improve clay soil by proper cultivation, and by working in plenty of dead plant material. Humus helps to make the soil lighter so that it dries more easily and so that air can get in through the soil. The roots of the crop plants also can then grow through the soil more easily.

Sandy soil. You can sit down on sand soon after a rain without getting wet where you sit down. Sandy soil is very loose. Water runs right through it. After



1. Keystone View Co., N. Y., 2, 3, 4, Ewing Galloway, N. Y.

The crop depends upon the kind of soil. 1. A wheat field, 2. Cranberry culture, 3. Harvesting potatoes, 4. Fruit growing.

a rain it soon dries out. Therefore, sandy soil warms up rapidly after rain and in the early spring, so that the crops grow easily. Sandy soil is valuable, therefore, to raise early spring crops. Well mixed with humus, sandy soil holds water much better, and becomes much richer in plant mineral food. The farmer may add the humus to the soil by spreading manure. Very often crops are grown and plowed under before they ripen to add humus to a sandy soil. Rye and clover are often used in this way as a "green manure."

Loam. The best soil for the farmer is a mixture of sand and clay. This makes *loam.* A loamy soil has good qualities of both sand and clay. It holds water better than sand, but does not easily become water-logged like clay. It warms up in the spring faster than clay and allows air to get in around the roots of the plants. Furthermore, it is easily worked. It generally contains a fair quantity of humus, and the farmer can easily add more.

Acid and alkali soils. In boggy land the soil is often very acid. Most crops cannot grow well in acid soils. A few, like cranberries, can. Potatoes and rye grow in soil that is slightly acid. The farmer can neutralize an acid or sour soil by adding lime. Bog soils, when properly worked, become very rich soils.

In dry or desert countries the soil is often alkaline. Few farm crops can grow in alkali soils. Generally, alkali soils are deserts with only desert plants. Some soils of our West are alkali soils due to the concentration of salts when salt lakes dried up.

Things to Do in Learning about Using the Soils

I. Read the chapter.

II. Study soils in field and laboratory.

1. Gather the various kinds of soils as suggested on page 142.

2. Examine the soils as suggested on pages 143 and 144. Draw up a table to record what you find out about soils.

Kind of Soil	What Happens in Water	Fine or Coarse Particles	Effect of Heating

3. Experiment No. 17.

Question: Are there living things unseen in the soil samples?

Materials: Beef extract or a small piece of beef; cotton; test tubes or wide-mouthed bottles; small pot; a quart tin can; soil samples; gas burner; tripod or support for pot (or the pot may be heated on stove); an old knife or small spoon to put soil in test tubes or bottles.

Directions: Make a beef broth by adding a little beef extract to hot water or by slowly stewing the beef. Put a little beef broth into each test tube or bottle, one for each sample of soil and one extra for control. Plug the mouths of the tubes or bottles with cotton. Sterilize the broth by heating the test tubes or bottles in the can or in a pot with water, but not enough water to boil over or wet the cotton stoppers. Boil for a half hour, and then allow to cool. Now carefully heat the knife blade or spoon in the gas flame until it is hot. This is to kill any bacteria on it. Then allow it to cool but do not allow the blade to touch anything. Remove the cotton stopper from a test tube or bottle, and hold it so that it touches nothing. Allow your fingers to touch only the outer part of the cotton, not the part that goes into the test tube or bottle. Hold the stopper. Do not lay it on the table where it would pick up bacteria. Put a little of a soil sample in the test tube and replace the stopper. Again heat the knife and add some of each of the other samples to test tubes. Heat the knife before each sample is touched. Put a label with the number of the soil sample on each test tube. On the extra test tube with broth, but no soil, put a label marked *Control*. Set all the test tubes away in a warm closet until next day or longer.

Results: Record in a table any change in the appearance of the broth. Note the appearance of the control.

Conclusion: Is there any evidence that there were bacteria or other microscopic life in the soil? What is the use of the control?

4. Experiment No. 18. See if any green plants will grow from the soil without your planting seed. Put some

of each soil in a small flowerpot. Keep the soil in the pots damp but not wet. Tend them as you would pots of flowers for two weeks. Do any plants grow from the samples? What living things must have been in the soil? Write a report of the experiment as in Experiment No. 17.

5. Experiment No. 19. Find out by experiment how various soils differ in their ability to hold water. Put the same quantity of soil in each of several small flowerpots, one kind in each pot. Set each pot in a glass. Measure a quantity of water, say a half pint, or 300 cubic centimeters. Pour the same quantity of water through the soil in each pot and collect the water which runs through. Allow the water to drop until it stops. Measure the water which runs through and calculate how much the soil retained. Write a report of the experiment in the usual form. Under the heading Observations, draw up a table like the following.



Apparatus for Experiment No. 19

Sample	Water Poured in	Water Recovered	Water Retained by Soil
Gravel			
Sand			
Loam			
Clay			

If you have no graduate, you may use a half-pint milk bottle or use a tumbler and mark on it in ink the level of the water.

6. Experiment No. 20. Find by experiment which kind of soil is best for growing plants. Put each kind of

soil in a flower pot. Plant in each several small seeds such as radish or oats or any other that is handy. Do not plant deeply, just cover the seeds to the thickness of the seed. Keep the soil moist but not wet. Watch for several weeks. Write a report as in Experiment No. 17.

III. Test yourself with the following questions:

1. What did you learn about soils when you stirred samples in water?
2. What did you learn by heating samples?
3. What did you learn by the experiment with beef broth and soil?
4. Write a list of soils, in the order of their ability to hold water.
5. Which of the soils in the list would warm up first in spring and start seeds and plants? Which would be slowest?
6. In dry weather, in which soil would plants suffer first?
7. Tell how the gardener could improve sandy soils. Tell how he could improve clay soils.
8. What is the best soil for the gardener or farmer?

IV. Think these out:

1. How are city people affected by soils?
2. List the things that you meet in a day that have come from the soil, directly or indirectly.
3. How would you make up a good soil for growing flowers in pots?

V. Vocabulary. Perhaps you "half-know" some of the words suggested here. Can you write out a meaning? Of course, add your own to this list.

sterile	organic	loam
sterilize	cultivation	alkali
	culture	



Ewing Galloway, N.Y. *Philip D. Gendreau, N. Y.*

CHAPTER FIFTEEN

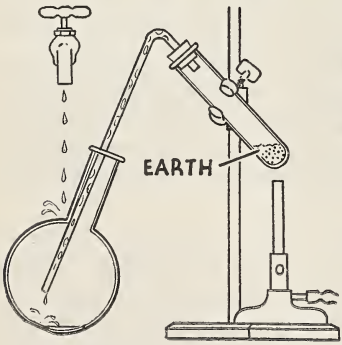
TAKING CARE OF SOIL

Soil needs care. A farmer must take care of his soil. It may be made rich or it may be made poor. Its condition and usefulness depend upon the farmer's knowledge of soil and his ability to take care of it. A farmer must know how particular kinds of soil influence the growth of his crop plants and what his plants do to the soil. He must give his soils a rest sometimes, just as he gives his horses a rest and rests himself. He rests his soil by changing the crop in a field from year to year and sometimes by allowing the field to rest for a time in grass. Thus in successive years a farmer may grow corn, oats, wheat, and grass. This changing of crops is known as the *rotation of crops*.

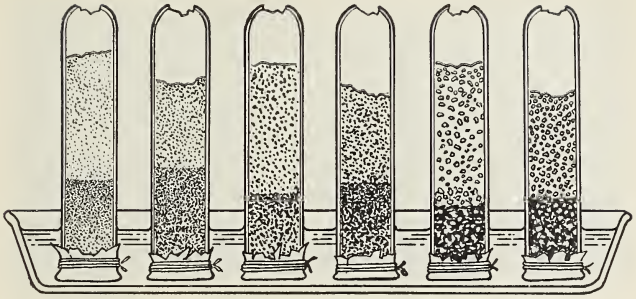
Soil water. "Dry as dust," you have heard it said. But dust may not be as dry as it looks. If you heat a little in a test tube as in the picture on page 152, moisture will condense on the cooler part of the test tube. Soils contain water even when they feel dry. It is this soil water that supports the plants.

Did you ever lay a clean bath towel carefully over the side of the tub, and later find it wet over half its length? When you examined it, you perhaps saw that only the tip end of the towel was touching the water. The water ran up between the threads. In a similar manner ink runs into the blotter between the threads of the blotting paper. In the same way, if you pack soil in a bottomless bottle and stand it in a dish with a little water, the water will run up in the soil much higher than the level of the water in the dish (see page 153). The finer the soil in the bottle, the higher the water will rise. So water will rise in glass tubes set in a tumbler of water. This rise of water in small spaces and tubes perhaps no thicker than a hair is called *capillarity* from the Latin word *capilla* which means "a hair."

If you dig far enough in the earth, you always come to water. The level of the standing water in the soil is called the *water table.* Water rises from the water table up through the soil by capillarity. The finer the spaces between the soil particles, the higher the water rises. It is the capillary water that supplies growing plants. As fast as the plants remove it from the soil, more rises to take its place, provided there is sufficient supply below. If the farmer allows the small capillary passages to extend to the surface of the soil, the water passes up to the air, evaporates, and is lost. The farmer reduces the loss of water by harrowing the soil, thus



Apparatus to prove that there is moisture in soil

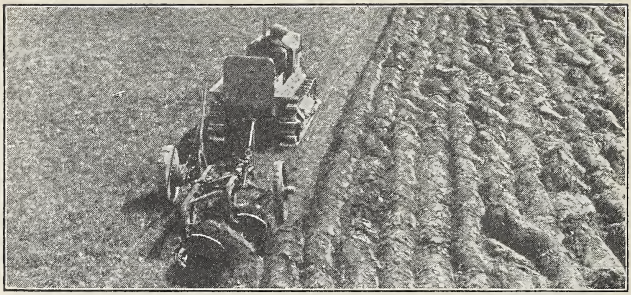


This picture shows how water rises by capillarity

breaking up the capillary passages so water cannot come to the surface.

Why the farmer tills the soil. Cultivating or tilling the soil by plowing and harrowing and working the soil in other ways aids the plants in several ways. It saves soil water. It loosens the soil so that tender roots may grow through the soil. It allows air to get into the soil more easily. Air is necessary for the living things in the soil, both plants and animals. Cultivation also turns up a fresh supply of soil so that more mineral food for the plants may weather out. Decay of dead plants to form humus is also aided by turning over the soil.

How worms and little creatures help the farmer. Did you ever dig earthworms to go fishing? There may be fifty thousand earthworms in an acre of good soil. That is worth a lot for fish bait, but they are worth a lot more to the farmer right where they belong, in the soil. They plow and harrow the soil for him, not the way he does, but by eating their way through the soil. They swallow the soil, digest anything in it that is digestible, and cast out on the surface anything that is indigestible. You can see their castings on the ground. Their loosening the

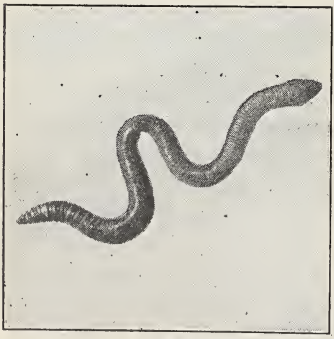


Caterpillar Tractor Co.

How does a farmer by plowing aid the growth of the seeds he will plant?

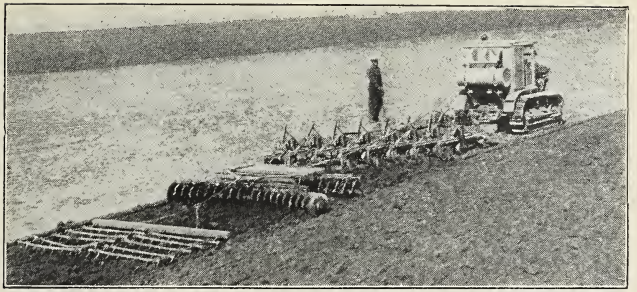
soil lets in air and rain. They drag bits of leaves down into their burrows and eat them. Then they return the waste to the soil, just as the farmer adds manure to the soil. Perhaps a single earthworm might be small help to a farmer, but fifty thousand of them will bring to the surface fourteen to eighteen tons of soil each year. They do not dig deeply enough to bring up worthless subsoil.

Even more important to the farmer are microscopic plants, the bacteria, and also the molds. They cause decay. These lowly plants feed upon the dead things in the soil, both plant and animal remains. Crops cannot grow upon these dead things. The bacteria and molds change the dead things into waste products which are the mineral substances which the crops need. These tiny plants are, therefore, continually enriching the



Hugh Spencer, Chester, Conn.

Each earthworm is a tiny but efficient plow

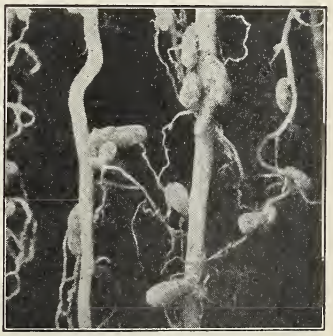


Caterpillar Tractor Co.

How does harrowing the earth help the growth of plants?

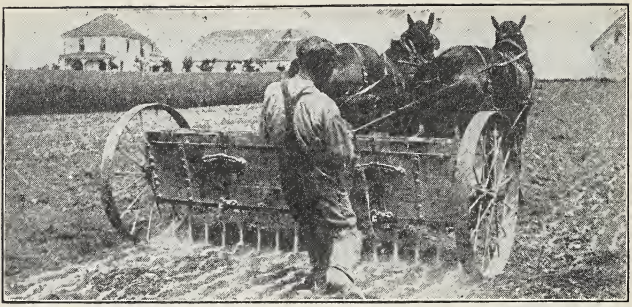
soil. If it were not for bacteria and molds, the soil would be covered over with dead plants and animals so that no crops could grow. The scientific farmer thinks well of the bacteria of his fields. The manure he spreads feeds them, and they pay for their food by returning to the soil the mineral which the crops took out. Cultivation of the soil supplies them with air and regulates the moisture so that they may live healthily. That is one reason for plowing and harrowing.

In addition to the bacteria of decay in the soil, there are other kinds of bacteria that aid the farmer. Some of them are the nitrogen bacteria that take nitrogen from the air and make it into compounds that the crop plants can use. Some of the nitrogen bacteria live on the roots of clover, beans, and alfalfa. Others live in the soil.



Hugh Spencer, Chester, Conn.

These little lumps are formed on clover roots by helpful bacteria



Ewing Galloway, N. Y.

Spreading fertilizer distributes food for helpful bacteria

When the farmer grows clover and alfalfa, he not only raises good food for his cattle but also good food for the bacteria which enrich his soil.

The good farmer remembers the lives of the little animals and plants in the soil. He feeds them with manure and other forms of humus. He cultivates the soil to give them air and water. On them depends the health of his crops, for the crops must have the good things which these small animals and plants return to the soil.

Things to Do in Learning about the Care of the Soil

I. Read the chapter.

II. Study care of the soil by experiment and observation.

1. Experiment No. 21. Heat some apparently dry soil gently in a test tube as directed in the chapter to learn if water is present.

2. Experiment No. 22. Tear a strip of paper towel. Lay over the edge of a dish with a little red ink in the bottom. Let the tip of the paper strip touch the red ink. Let it stand for awhile. What happens? What is the name of the process shown?

3. Experiment No. 23. What effect has fineness of soil on capillarity? With a glass rod, punch the bottoms

out of six test tubes. Tie a thin piece of cloth over the bottom of each. Thoroughly dry over a flame some coarse soil, some medium fine soil, and some fine soil. Fill two test tubes with coarse soil, two with medium, and two with fine soil. Pack the soil tight in one of each pair of tubes and in the other have the soil loose. Set the tubes in a vessel containing water colored with ink. Allow them to stand until the water no longer rises and then measure the height of water in each tube. Write up a report in the usual form.

(Alternative experiment. Pour a little ink in a dish and set in a lump of sugar. Set in a second lump of sugar and cover loosely with granulated sugar. Try a third lump covered with pulverized sugar.)

4. In your garden or in window boxes, learn the effect of cultivation by regularly cultivating a part of the garden and leaving another part untouched. If your garden is in window boxes, you might cultivate one box and leave another uncultivated. In this experiment give the window boxes much less than their usual water supply.

5. Dig into various types of soils to learn how far below the surface the soil is dry (not moist). Record your findings in your notebook and report to your class.

6. If you are not familiar with farm work and garden work, paste in your notebook pictures of farm and garden implements and below each tell how each type benefits the soil.

7. Refer back to your studies on the living things of the soil in Chapter Thirteen and Experiment No. 16.

8. Pull up from loose soil a few clover or alfalfa plants to search for the nodules on the roots in which the root bacteria live. Growing wild in the woods you may find plants that look like bean plants and like them have bacteria living on the roots.

III. Test yourself with the following questions:

1. How is the farmer benefited by changing the crops in his fields year after year? What is the process called?

2. What did you learn by Experiment No. 22?

3. What did you learn by Experiment No. 23?

4. List the benefits of cultivating the soil.

5. How do other living things in the soil help the crops? How does the farmer help these other living things?

IV. Think out the answers to the following questions:

1. Mention some other common occurrences of capillarity.

2. What kind of soil would a farmer roll with a heavy roller? Why?

3. Why is it that if a farmer does not add manure or other fertilizer to his fields, his crops gradually decrease while forests grow luxuriantly?

V. Vocabulary. You probably know some of the words suggested, and perhaps you have found others in the chapter which were not quite familiar to you. Make up your own list, using the words which you need to study.

rotation	capillary	tilling
rotation of crops	capillarity	burrows
successive	water table	luxuriant



UNIT VI

AIR

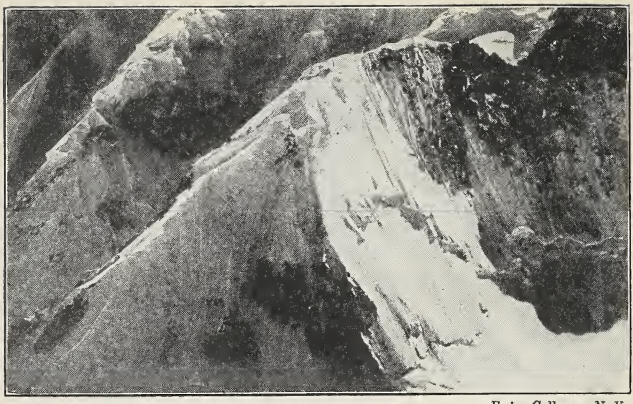
ANOTHER of the common things about you is air. It is common enough wherever you have been. Like soil and water it is a necessity of life on this solid earth. You might live without soil until the supply of stored food was exhausted. You could live for a shorter time without water, a very short time. You could live about one half a minute without air.

What is this stuff so necessary to life? Why is it necessary? What does it do in the body?

If it is so important in its effect on living things, does it affect things that are not alive?

You have seen that water and soil, other necessities of life, need to be taken care of. Do we need to take care of air? There seems to be plenty of it about. "Free as the air," we say. If you go to a large modern school you perhaps have seen expensive apparatus that is used to keep the rooms supplied with air. Perhaps you have gone from a hot street into the cool air of a modern "movie" theater or an air-conditioned store. Supplying air to large buildings where people gather in hundreds or thousands is a problem for engineers. Keeping your home supplied properly with air is a much easier problem.

In this unit we shall study the questions suggested and some others. Does the wind blow where it pleases or where it must? Why does it blow? "Light as air," we say. Were you ever hit by a heavy wind? How much does air weigh? How do we use its weight?



Ewing Galloway, N. Y.

CHAPTER SIXTEEN

WHERE THE AIR IS AND WHAT IT IS

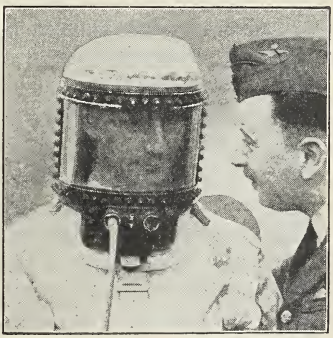
Where is the air? Air is everywhere about us, all around the earth. It is up and up above us. On the highest mountain man has climbed, 28,000 feet on the slope of Mount Everest, there is air. As high as man has flown in an airplane—almost nine miles—there is air. As high as man has been carried by a balloon—almost fourteen miles—there is air. As high as a balloon has risen without a man—twenty-four miles—there is air.

There is air far beyond the height that man has attained. Astronomers can measure the height of a flaring meteor. Meteors flash because they get hot going through the air. Meteors have flashed 150 miles above the ground. Therefore, there must be air that high; how much higher we do not know. Perhaps the air reaches 400 miles.

However, there is less air up above. If you try to climb high mountains, only two miles high, you get out of breath very easily, because the air is thin. Climbers trying to reach the top of Mount Everest,

over five miles high, carried tanks of oxygen to breathe, for the air was too thin for comfortable breathing, even though they did not reach the top. Aviators flying to great heights also carry tanks of oxygen, for the thin air would not keep them alive. Although the air gets thin as you ascend, there is still air as high as men have gone.

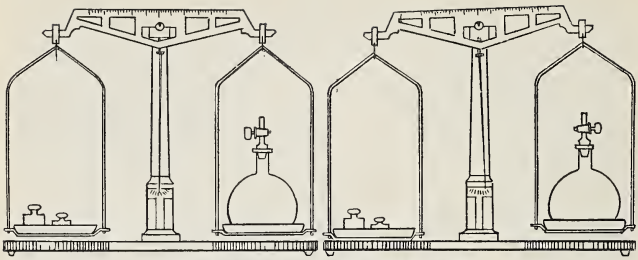
There is air below us, underground. If you take half a glass of soil and pour water in, you can see air bubble out of the soil. Air goes into the soil we walk on. It goes down deeper. It goes into the deepest mine that has been dug. It goes into the water of lakes and the ocean. You can see that there is air in the water that you drink. Set a glass of cold water in a warm room for half an hour. The little bubbles you see on the side of the glass are due to air that is coming out of the water, for as the water warms, it cannot hold so much air, and the air comes out in bubbles. It is the air in water that the fish breathe. If you boil water and cool it without shaking it and then place fish in it, they will come to the surface and gasp for air. Boiling drives out the air and the fish take mouthfuls of free air above the water. Fish live two miles deep in the sea; there must be air for them to breathe down there.



Ewing Galloway, N. Y.

Aviators who fly to great heights must wear oxygen masks

Heavy as air. Air is heavy, if you get enough of it. Try picking up an automobile tire, first flat and then pumped hard. It is not difficult to find how much air



Apparatus to show that air has weight

weighs. If you weigh a glass flask like that shown in the picture above, then pump the air out of it with an air pump and weigh it again, you will find the weight of the air that was in the flask. Actually you can never pump all the air out, but you can pump by far the largest part of it out. Then, if you find the volume or size of the flask, you can figure out how much a cubic foot of air weighs. It has been found that a cubic foot of air if taken at sea level weighs a little over an ounce. If you took the cubic foot of the air on the top of Pike's Peak, it would weigh less because the air is thinner there. The air in a room of an ordinary six-room house at sea level weighs over two hundred pounds, and the air in the whole house weighs about eight tons.

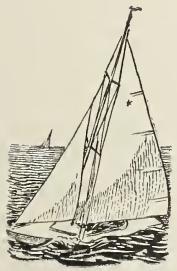
How much does the air weigh that a man carries around on the top of his hat? To make the problem simple, let us suppose that it is his old straw hat with a flat top, and let us not count the brim, just the crown. It is about 6 inches in diameter. Then its area on top is about 3×3^2 or 27 square inches. How much air is pressing on the 27 square inches? On every square inch at sea level all the air over that square inch to the top of the atmosphere is pressing down. That pressure has been measured. On every square inch at sea level the pressure of the air is 15



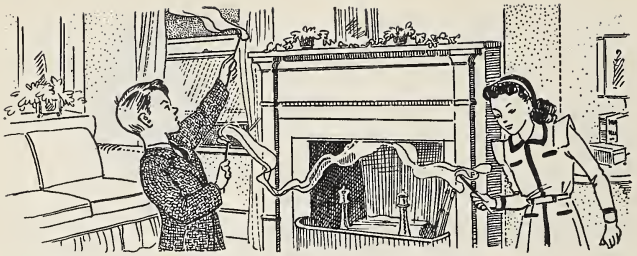
How does he do it?

pounds. On the top of the straw hat, there is a pressure of 27×15 pounds, or 405 pounds. He carries over 400 pounds on the top of his head. How can he do it? There is air inside the hat. There is air inside him. In fact he is full of air. Air pressure outside is pressing upward under his straw hat with the same pressure that the air is pressing down, 15 pounds to the square inch. Just as air penetrates soil and water, so it penetrates his body. Therefore, although the air is pressing the hat down with a weight of 400 pounds, it is also pressing it up at the same rate. No wonder he does not notice that 400 pounds.

Why the wind blows. If you were ever hit by a strong wind, you know that wind has force. Perhaps you have seen a child tumbled over by a strong wind or have seen wind blow an automobile to one side. Sometimes it will pick a man off his feet or carry a house away. Wind drives boats, big ships, and windmills. It raises great waves that break down sea walls.


The force of the wind

Investigate the gentle movement of air about the house or schoolroom. Tie a narrow, light ribbon of tissue paper to the end of a pencil like a pennant or flag. With this indicator examine the movement of air currents. Or use a smoking stick of punk as an indicator.



This boy and girl are studying air currents. Try this experiment in your schoolroom or at home.

Hold your punk-stick indicator above the radiator. In what direction is the air moving? Hold it below the radiator and determine the direction. Hold it to one side. Try the movement around a stove or a gas burner. Try around the windows and doors. Open a window a little way at the top and test the air currents, and then test them with the window open at the bottom.

You will find that air is moving up where it is heated and down where it is cold. Across the floor it moves from the cold to the heated places. If such a movement is strong enough, we call it wind. If there is a cold area on the earth and a hot area we expect to find winds blowing. If there is a great enough difference in temperature and if the areas are close enough together, the wind may be very violent.

If you place a cork in an empty basin and then pour in water, the water flows under the cork and raises it because the water is heavier than the cork. Similarly, cold air flows under and lifts hot air because the cold air is heavier. The flowing in of the cold air is wind.

Sometimes the air becomes heated so quickly over a hot region that cooler air blows in with such violence that a whirling storm is set up. These whirling



Philip D. Gendreau, N. Y.

The trail of a tornado

storms are *tornadoes*. They may be so violent that they tear houses to pieces and carry the big timbers sailing through the air. They may pick up men and animals and toss them about or carry them along for some distance. The course of a tornado is a path of destruction across the country and through towns, marked by leveled houses and uprooted trees.

What is air? If you have ever thought what air is, you probably thought that air is just air. The scientist does not think that way. He has tried to find out what air is, and he has found out that it is made up of a number of things. These things are gases mixed together. Most of the air, about four-fifths of it, is a gas called *nitrogen*. About one-fifth is *oxygen*. About one four-hundredth is the gas *carbon dioxide*. A very small part of air is *neon*, the gas that fills the red tubes in the electric sign. There are some other gases in the air in very small quantities.

There is also water vapor in the air. You found that by experiment when you took a cold mirror out of the refrigerator. The amount of water vapor varies very much. Sometimes the air seems very clear and at others very hazy from water vapor. At

still other times so much water vapor may be present in the air that it falls as rain or snow. The amount of water vapor also varies with the part of the earth. There is usually much more at the seacoast than in the interior of the continent. In the desert there is very little moisture in the air.

There are other things floating in the air. In one city studied, over a thousand tons of coal dust fell each year on a square mile. In the drought years, dust clouds covered the sun and the dust came into houses through the closed windows. Floating in the air, also, is a dust from many kinds of flowers, the pollen. Certain kinds of flowers, such as those of the ragweed, give off a pollen that causes hay fever in some persons.

Things to Do in Learning Where the Air Is and What It Is

I. Read the chapter.

II. Study the air by experiment and calculation.

1. Draw a circle eight inches in diameter to represent the earth 8,000 miles in diameter. How high does the air go above the surface of the earth? Calculate how much farther from the center of your diagram you would need to draw a second circle to represent the atmosphere. Try to draw it.

2. Draw a diagram showing the height to which the following reach: Mt. Everest, mountain climbers, airplanes, men in balloons, balloons without men, the air. Indicate by shading or dotting how the air gets thin as you go up.

3. Experiment No. 24. Show that there is air in the soil as directed on page 161.

4. Experiment No. 25. Show that there is air in water as directed on page 161.

5. Experiment No. 26. How much does the air in a football weigh? Weigh the empty football. Pump it hard and weigh it again.

6. Calculate the pressure of the air on the top of the table or desk on which you are working.

7. Recall Experiment No. 7 in which you showed that there was water in the air when you could not see it.

8. Draw a chart of your room and put in doors, windows, and radiators. Indicate by arrows the currents. Locate the air currents as suggested on page 163.

9. EXPERIMENT No. 27. Do hot air and cold air weigh the same? Weigh a large, uncorked flask cold. Then heat it very hot and weigh it again. The difference between the weights of small quantities of hot and cold air is so slight that the flasks should be large and the balance delicate.

III. Test yourself with the following questions:

1. How high does the air go? How do we know?

2. Why do aviators and mountain climbers have difficulty breathing at great heights? How do they overcome the difficulty?

3. What did you learn by Experiment No. 24?

4. What did you learn by Experiment No. 25? How else could you demonstrate the same thing?

5. How could you find out what air weighs? How much does a cubic foot weigh?

6. Does the air pressing down on your head weigh much or little? About how much?

7. Tell what gases make up the air and give some idea how much of each.

8. How can you show that there is water vapor in air?

9. How can you show that there is dust in the air?

10. Where does the wind blow? Why does it blow?

IV. Think these out:

1. Why is there less air up above?

2. Would the air weigh more or less at the bottom of a deep mine than it does at the surface of the earth?

3. Suppose you filled a toy balloon with air at the seashore and then carried it to the top of a very high mountain. Would the balloon be the same size as at sea level?

V. Vocabulary. Did you find any words to add to your word list?



Ewing Galloway, N. Y.

CHAPTER SEVENTEEN

HOW OXYGEN BEHAVES

What makes a candle burn? If the wind were trying to blow your candle out, you might get the idea of protecting it by turning a jar upside down over it. What would happen? If you do not know, try the experiment. The candle soon goes out. If you have any experience with a coal or wood stove, you know how to hurry the fire by opening the draft door at the bottom of the stove or furnace. You also turn the damper in the smoke pipe so that the draft goes freely up the chimney. If you have had no experience with a coal fire, perhaps you have tried to light a campfire or a picnic fire, and to make it burn you fanned it briskly with your hat. If you have had neither experience, try two experiments.

In the first experiment, lower a lighted candle into a jar and let it burn for a considerable time. (Experiment No. 28.) In the next experiment stand a lamp chimney on low pieces of wood or nails as in the picture. After you have watched the candle for a

time and noticed any difference from the behavior in the first experiment, try gently fanning the chimney at the bottom. Then notice any difference in the burning of the candle.



What makes the candle burn?

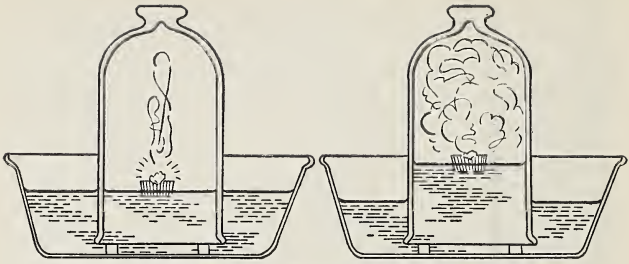
From these experiments you may conclude (1) that there is something in the air that makes the candle burn; (2) that this something disappears as the candle burns in an enclosed space; (3) that when you give more air to a fire it burns briskly.

Air that disappeared. Place some phosphorus on a piece of tin and gently place the tin on top of a cork floating in a dish of water (page 170). Place a jar over the cork as in the diagram, and mark or measure on the bell jar the height to which the water rises. Now remove the bell jar carefully, light the phosphorus, and immediately replace the bell jar. When the phosphorus stops burning, note the position of the water against the side of the jar. About one-fifth of the air has disappeared. Phosphorus is dangerous. You may get a bad burn from it. To avoid danger you may use iron filings instead, but the experiment will take longer to perform.



Why does fanning the fire help to kindle it?

Wet a test tube inside and pour the water out. Then put some iron filings in the wet tube and roll them around so that the inside of the test tube is coated with iron filings. Set up this test tube as shown on page 170.



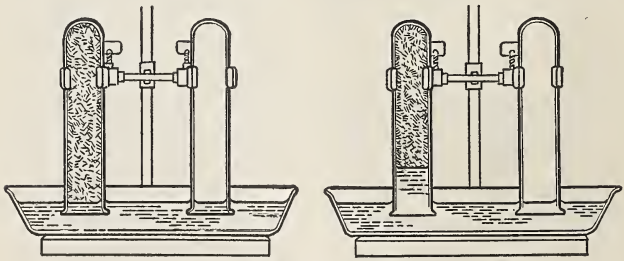
This experiment shows that about one fifth of the air is oxygen

Adjust the test tube so that the water stands at the same level inside and outside the test tube. Mark the position. Set up another test tube in the same way, without iron filings, as a "control."

Let the apparatus stand until next day. Then see how much air has been used up. You will notice that the water stands higher in test tube with iron filings. About one fifth of the air has disappeared. In the control the air is still all there.

The fifth of the air that disappeared is oxygen.

Making new substances. Now look again at the test tube in which you put the iron filings the day before. The clean dark-colored iron is no longer there. A new brown substance is there instead. Of course you say that the iron has rusted. But this



Rusting is a form of oxidation

iron rust is a new substance. It is a substance which contains iron and oxygen and was formed by oxygen uniting with the iron. The brown substance is iron oxide. If you throw a piece of iron on the back lot, it will rust. If you keep it in a dry place it may be kept without rusting. Water helps the oxygen to unite with the iron.

Let us try another experiment. (Experiment 29.) Let a candle burn for a time in a jar as on page 168. You need not wait until the candle goes out and smokes. Remove the candle without overturning the jar and pour a little limewater into the jar and shake it around. Pour the same quantity of limewater in the second jar, as control, and shake it around. You will see that the burning candle did something to the air that makes the limewater turn milky. Limewater turns milky when carbon dioxide meets it. Therefore, carbon dioxide must have been made by the burning. You will notice that after a time limewater in the control jar also turns slightly milky. This shows that there is a little carbon dioxide in the air, but that the burning candle produced much more. The candle contains the element carbon which unites with the oxygen of the air and forms the new substance *carbon dioxide.*

When you burned the phosphorus under the bell jar, white smoke was formed. This white smoke is a new substance that is formed by oxygen uniting with phosphorus. It is phosphorus oxide.

Oxygen alone. Now let us study oxygen when it is not mixed with the rest of the air. We can prepare some oxygen by breaking apart an oxide. There is an oxide of mercury that can be easily broken apart. Mercury, or quicksilver, is the silvery liquid that is used in thermometers. This oxide of mercury is a red powder. Put some of the red mercury oxide

in a test tube and heat it. After heating the tube vigorously, light a splinter of wood and shake out the flame but leave the wood glowing red. Insert this glowing splint into the test tube. It bursts into a bright flame. Oxygen coming from the mercury unites with the wood and the wood burns brightly. If you look on the cool part of the test tube, you will see a silvery deposit somewhat like a mirror. This is mercury. The experiment shows us several things: (1) Heat breaks up the red powder; (2) A gas is given off that causes a glowing splinter to burst into flame. This is called the *spark test.* We know that this gas is oxygen; (3) Mercury deposited on the test tube shows us that the red powder also contains mercury.

Oxygen in action. To secure oxygen in quantities for experiment we may use another compound of oxygen, potassium chlorate. Experiment No. 32 tells how to prepare and collect the gas.

If in one bottle of gas we try the "spark test" as we did with one in the last experiment, we see a glowing splinter burst into flame. That shows us that the gas is oxygen. Look at the gas. It looks like air, that is, it is colorless. It smells like air, that is, it is odorless. It tastes like air, that is, it is tasteless. If you shake a little limewater in a jar of oxygen, nothing happens. If you shake a little limewater in the bottle in which you tried the spark test, it becomes milky. Carbon dioxide has been formed when the wood burned. Heat a piece of charcoal to redness and lower into a second jar of oxygen. The charcoal bursts into flame and produces carbon dioxide.

In a third bottle lower a little burning sulphur on a long iron spoon (deflagrating spoon) as in the picture. The sulphur burns much more vividly in

the oxygen. The oxygen unites with the sulphur to form sulphur oxide. Even iron will burn in pure oxygen. Try it in a third bottle. Take a piece of iron picture wire made of several strands of fine wire. As the iron does not start to burn very readily, we must give it a little start. Heat the end red hot, touch it to a little sulphur, and then light the sulphur and quickly thrust the wire into the jar of oxygen. The iron, after it starts burning, burns brilliantly for a short time and sparks fly about. Iron oxide is formed.

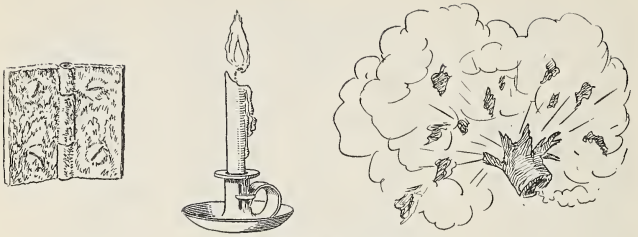


Burning sulphur in oxygen

You might think that if air is good to breathe, pure oxygen is better. The experiment was tried with a mouse. The little animal seemed to enjoy it. He jumped around and was quite lively for a time. But in a few hours he was dead. He lived too fast. If our kitchen were filled with pure oxygen, the fire would burn too fast. The stove would get too hot. The food on the stove would burn up. Even the stove would be in danger of taking fire.

Oxygen, pure or nearly pure, is sometimes given to patients whose lungs cannot get enough oxygen from the air or whose blood cannot carry enough oxygen from the air. It is used by aviators and mountain climbers to enrich the thin air at great altitudes. But for normal people at ordinary altitudes, it makes things go too fast; air is better because it is more dilute (weaker).

Most of the air is not oxygen. The chief gas in the air that dilutes the oxygen is nitrogen. It is difficult to make the nitrogen of the air unite with anything. The nitrogen prevents us from living too



Three forms of oxidation

fast like the mouse in the jar of oxygen. It prevents things from burning up too fast in the kitchen and from rusting too fast. It keeps us alive by preventing us from getting too much oxygen.

Joining with oxygen. The union of oxygen with another substance is called *oxidation*. The union may take place very gradually as when a piece of iron rusts. It may take place so rapidly as to produce light and heat as when a candle burns. It may be so brisk as to produce a good heating fire as when coal or gas burns. It may be instantaneous as when gunpowder or gasoline explodes.

Oxidation is exceedingly valuable to us. We heat our homes by oxidation. We drive locomotives and automobiles and run the machinery of factories by oxidation. By oxidation, as well as by water power, we run dynamos that produce electricity.

The fire inside you. Your body feels warm. A thermometer under the tongue shows a temperature of 98.6° F. when the temperature outside is 70° or freezing or 30° below zero. Something is constantly keeping you warm. It is the same process that makes the fire warm, oxidation. Inside you oxygen is uniting with something else and giving out heat. That is what becomes of the oxygen that you breathe in with the air. The things that are oxidized

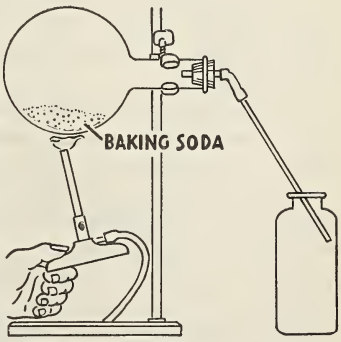
are in your food and waste materials. The oxidation inside you is slow, of course, but it produces heat.

When food burns up inside you, carbon dioxide is produced. You breathe it out. You can easily show carbon dioxide in your outgoing breath by blowing through a tube into a little limewater in a glass.

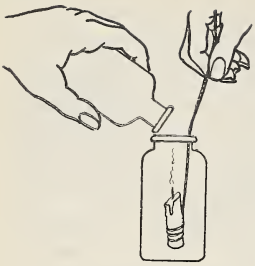
Carbon dioxide. With two billion people on the earth and many, many times that number of animals breathing out carbon dioxide, and all the fires of homes, factories, railroads, steamships, all the automobiles and airplanes, the forest fires and burning buildings continually sending carbon dioxide into the air, it is not much wonder that we can find that gas in the air. But there is surprisingly little of it in the air. Only about one four-hundredth of the air is carbon dioxide.

We can prepare carbon dioxide for study by heating some baking soda, as in the picture, or we can prepare some as in Experiment No. 35. Collect several bottles of the gas as it comes off. To show that it is carbon dioxide, pour a little limewater in one of the bottles and shake it around. Look at a bottle of the carbon dioxide that you have collected. You cannot see the gas, smell it, nor taste it.

If you lower a burning splint into a bottle of carbon dioxide, the flame promptly goes out. You learn that carbon dioxide does not burn but puts out fire. Light a candle and set it in a jar. Take a bottle of carbon dioxide and pour it on the candle. You will



Preparation of carbon dioxide



Pouring carbon dioxide

not see the carbon dioxide flow into the jar, but you will see the candle go out. You learn that you pour carbon dioxide downward as you pour water. It, therefore, is heavier than air. The heavier carbon dioxide forces the air out as water would. The fire then, having no oxygen, goes out as shown in the picture on the left.

Things to Do in Learning How Oxygen Behaves

I. Read the chapter and experiment.

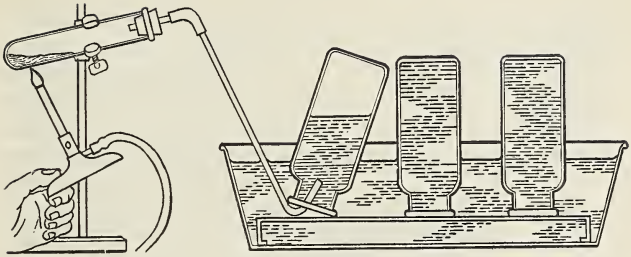
1. Experiment No. 28. Is there something in the air that makes a candle burn? Perform the experiment described in the chapter. Write the report in the usual form.

2. Experiment No. 29. What happens to the air when things burn in it? Fasten a candle to a small flat stone. Place in a pan. Light the candle. Lower a jar over it, preferably a narrow jar. Pour water gently into the pan until it rises almost to the top of the stone. Watch what happens to the water as the candle burns. How much of the jar filled with water? Write the report.

3. Experiment No. 30. What new substance is formed when a candle burns. Carry out the experiment suggested in the chapter. Write the report of the experiment in the usual form.

4. Experiment No. 31. How does oxygen differ from air? Heat a little mercuric oxide vigorously in a test tube. Write the report in the usual form. Try the spark test.

5. Experiment No. 32. To learn how to prepare oxygen and learn some of its properties arrange apparatus as shown in diagram opposite. Mix well one-half ounce of potassium chlorate and one-fourth ounce manganese dioxide. Tilt the test tube slightly. Tap the test tube gently to make a channel along the material to allow the gas to escape. Failure to take such precaution may lead



Preparing oxygen

to an explosion. Heat gently, keeping the flame moving constantly. Fill several bottles with water, cover them with plates of glass, and invert them in a pan of water. Collect the gas as shown. Cover the bottle filled with oxygen with a plate of glass, and then set it right end up on the table still covered with the glass.

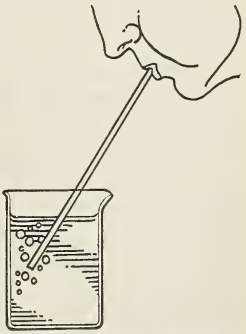
Learn the properties (characteristics or peculiarities) of oxygen. What color is oxygen?

In bottle No. 1 try the spark test.

Heat a piece of charcoal to redness and lower into bottle No. 2. Note what happens. Add some limewater to the bottle and shake. What is shown?

Into bottle No. 3 lower a little lighted sulphur in a long-handled spoon (deflagrating spoon).

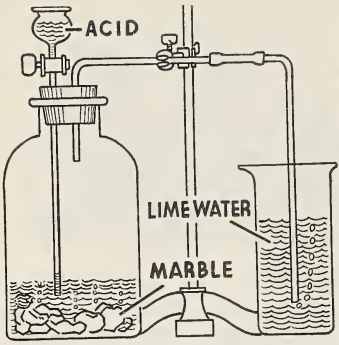
Heat the end of a piece of picture wire to redness, touch it to a little sulphur, and lower it burning into bottle No. 4. Write up the report in the usual form, showing the results in a table.



Showing carbon dioxide in the breath

6. EXPERIMENT No. 33. How is the air changed in breathing? Carry out an experiment and write a report.

7. EXPERIMENT No. 34. What part of the air is oxygen? Look back at your results in Experiment No. 29. Carry out the experiment



Making carbon dioxide gas

with iron filings and write a report.

8. Experiment No. 35. To prepare carbon dioxide and study its properties. Arrange apparatus as shown in diagram. Put some marble chips or baking soda in the flask. Pour in enough water to cover the chips. Then gently pour in some hydrochloric acid through the funnel tube. Bubbles of gas will come off.

Learn by experiment: 1. How carbon dioxide affects a burning candle. 2. Whether carbon dioxide is heavier or lighter than air. Write a report in the usual form.

II. Test yourself with the following questions:

1. Why does the burning candle go out when you lower it into a jar? Why does it not go out under the lamp chimney raised on sticks?

2. How much of the air disappeared when something was burned in a jar? What was that which disappeared?

3. What new substance appeared when iron was left moist in the air? What is the chemical name for the new substance?

4. What new substance did you find formed when a candle was burned? How could you show that a new substance was formed?

5. How can you prepare oxygen? How can you show that oxide of mercury is made up of two substances forming one substance?

6. How can you test for oxygen?

7. Does oxygen unite readily with other substances? How can you show that your answer is true? What is the chemical name for the union of oxygen with something else?

8. What use do we make of oxidation in our homes and in industry? How does nature use oxidation in our bodies?

9. How is the carbon dioxide that we breathe out formed? How, in our homes and industry, is carbon dioxide formed?

10. How can we prepare carbon dioxide for study? How can you show that carbon dioxide is in a bottle? Is carbon dioxide heavier or lighter than air? How can you prove your answer?

III. Think out the answers to these questions:

1. Why does oil on a knife blade keep it from rusting?

2. Out of what two elements is carbon dioxide formed in the body? in the stove?

3. If carbon dioxide puts out fire, could it be used in a fire extinguisher? Think of the apparatus you used in Experiment No. 35 and try to make a fire extinguisher. Baking soda may be used instead of marble chips.

IV. Vocabulary. Some suggestions for your word list. Remember to add your own.

oxide oxidation properties



Philip D. Gendreau, N. Y.

CHAPTER EIGHTEEN

BAD AIR AND GOOD AIR

Many kinds of dust. Dust is everywhere—dust on the table and window sill; dust on the floor and the wall; dust on the chairs and the sofa; dust on the stairs and hall; dust on the books and the pictures; dust on the clothes in the closets, and on those in the bureau drawers.

Clean it up, and it falls again. Clean every few days, and dust is always there when you look for it. Leave things ever so clean this week, you find dust again next week.

Dust is everywhere outdoors—on the porch rails, the floor, and the steps; on the car and garage windows; on the barn, the gates, and fences; on the trunks and the leaves of the trees; dust on the grass and the flowers. We even see it in the sunbeams.

Dust comes from the roads and the streets; from the grinding wheels; from the plow and the harrow; from the car and the horses' hoofs; from the locomotive; from chimneys of factories and homes; from

building of houses and from tearing them down; from digging of post holes and filling them in; dust from volcanoes and meteors; from the lands of drought.

Living dust flies on the wind—the pollen of flowers, from ragweed, grasses, and willow, from oak, hickory, and pine; pollen that starts seeds forming in the flowers to which it is blown; pollen that starts hay fever in some people who breathe it in. Dustlike spores come from molds and start the mold growing on bread when it is moist and warm, on fruit, and on old wet shoes. Dustlike spores come from yeast and start the yeast growing in fruit juices and other moist foods. Microscopic dust comes from germs of disease blown from sick people to healthy people.

Studying dust. You can easily gather dust from the air and study it with a lens or microscope. Lay freshly cleaned pieces of glass or plates in several places, by the closed window, on the table, in the closet, and outdoors. The dust will stick better if you melt a little gelatine in warm water and flow it over the plates. Next day examine the plates with a microscope, if you have access to one, or with a lens or magnifying glass. Mix beef broth with the gelatine and watch bacteria grow on your plates (Experiment No. 36). You do not see a single bacterium on the plates, bacteria are too small to see without a microscope; you see colonies of millions of them.



Keystone View Co., N. Y.
Two varieties of ragweed

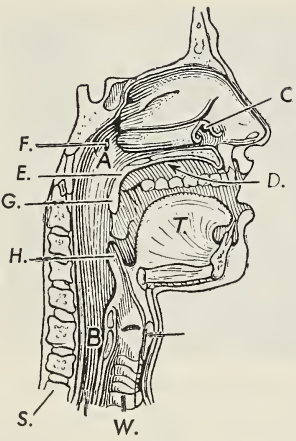
Scientists have studied dust in a similar manner. They have measured the quantity that falls. They have determined the kinds of pollen that are floating in the air when people are sneezing with hay fever. They have found what kinds of disease germs are floating around in the air.

Breathing the dust. We breathe that dust, the pollen, and the disease germs. Little wonder that we get colds and more serious illnesses. Dust settles on our food; little wonder that bread molds, fruits decay, meat spoils, and milk sours.

Nature has fitted us with dust stoppers, if we use them. Our nasal (nose) passages are lined with moist membrane. A moist substance, mucus, constantly passes out through the membrane that lines the air passages. Dust is held on the moist membrane. Our nasal passages are curved and fitted with scrolls of bone covered with mucous membrane. Forests of hairs grow in the nasal passages helping to stop the dust. But if you breathe through the mouth, you take the dust and disease germs and the cold air down into the delicate membranes of the throat and the still more delicate membranes of the lungs. The membranes of the air passages are covered with fine, microscopic hairlike growths that constantly wave. These microscopic hairs are called *cilia*. Their constant waving carries up from the air passages and into the throat the finest dust that is carried in. But these cilia should not be overloaded by the heavy dust breathed in through the mouth. The cold air in winter, too, is dangerous to the delicate membranes of the lungs. The air should be warmed by passing in through the nose.

If a child constantly breathes through his mouth, it is probably due to growths in the rear of the nasal passages. These growths are called *adenoids*. They

may be easily removed by the doctor, and without pain. They must be removed to give the child good health. Children with adenoids usually have poorly formed faces and jaws and dull minds. Such defects if due to adenoids can easily be remedied, but it must be done when the person is young.

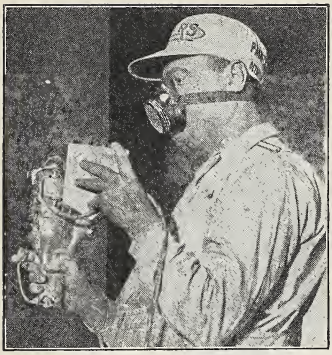


The nasal cavity and throat

A, opening of nose into throat; B, tube to stomach; C, bone scrolls in nose; D, E, roof of mouth; F, tube to ear; G, soft palate; H, entrance to windpipe; W, windpipe to lungs; T, tongue; S, backbone.

Dusty, dangerous jobs. Some occupations, like mining, stone cutting, and glass grinding, are especially dangerous because of the dust the workmen breathe in. "Black lung" is a tuberculosis or "consumption" of coal miners due to tuberculous germs which easily get a foothold in the delicate tissue of the lungs injured by the sharp coal dust. "Silicosis" is a similar disease of workers digging in rocks and tunnels and is caused by the fine sharp dust cutting into the lungs. Sometimes the workers amid such dust are provided with "aspirators" which remove the dust from the air they breathe.

Taking care of the air. Indoor air needs to be taken care of to make it fit to breathe. Its temperature should be somewhere between 65° and 70° F. for dwelling and schoolrooms. If one must do active work indoors, the temperature should be lower. Modern heating plants for homes and other buildings easily keep the temperature up in winter. Indeed



Ewing Galloway, N. Y.
A workman wearing an aspirator

we are in more danger of houses too warm than houses too cold. Thermometers should be kept in the rooms that we occupy, and if the temperature goes too high, the heat should be shut off or the room should be cooled. Temperatures of 80° F. or above, sometimes maintained in homes, are too high for comfort and health.

A hot, "stuffy," crowded room fairly makes the perspiration ooze down your back. Perspiration evaporating into the room makes it seem hotter, more stuffy. The odor adds to the annoyance. That is the place to get a cold. The "cold germs" are sure to be there, and if you go out into a cold wind with underwear dampened with perspiration, you may be chilled and the "cold germs" given an easy start in your body.

Moisture in the air makes you hot on a warm day and cold on a cold day. On the other hand, if the air is too dry in a room, it is very uncomfortable. The mucous membrane of the nose and throat feels dry and irritated. We may get decidely irritable. The heating engineers tell us that a humidity (moisture) of about 50 to 60 per cent is best, with a range anywhere from 40 to 70 per cent acceptable.

Now let us see what they mean. If the air has all the water vapor that it can hold, no more water will evaporate. The humidity is 100 per cent. The air is saturated. If the temperature is lowered, the air cannot hold so much water vapor, and some of it is

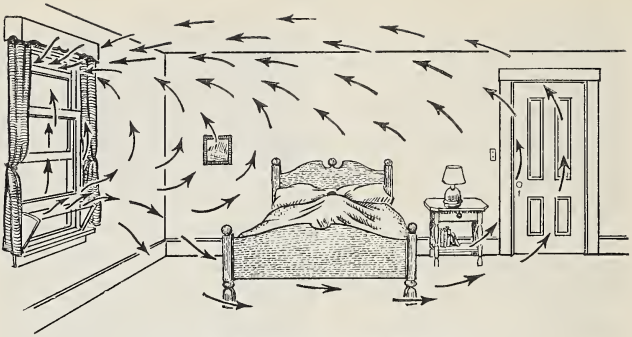
deposited. You remember how the water vapor was deposited on the cold glass, because the air next to the glass was chilled. If the temperature of the air is raised, it can hold more water. Therefore, when we say the humidity is 70 per cent we mean it is 70 per cent saturated at that temperature. We say that the 70 per cent is the *relative humidity.*

In large buildings, as in large theaters, the humidity may be regulated by allowing the air that is sent into the building to evaporate water by passing it through a spray. In our homes we seldom make any provision for moistening the air. If the air seems too dry, it can be improved by opening the window a little top and bottom.

Poisonous gases in our homes. Gases from fuels are another danger to health in dwellings and larger buildings. When coal and oil burn, several gases are produced. One of them is carbon dioxide. We are usually in no danger from this gas because it does not become sufficiently concentrated. Another gas, however, carbon monoxide, is very dangerous. It is colorless and odorless. It is extremely poisonous even in small quantities. When there is not sufficient air going into the furnace or gas stove, carbon monoxide is not burned up. If there is sufficient air, it burns up and forms carbon dioxide. Very often traces of carbon monoxide escape into our dwelling rooms from fires. It is also formed by automobile engines, and therefore they should never be run in closed garages, nor should all the windows of a car be kept closed when the engine is running, especially when idling. Other gases, especially gases containing



This oil heater gives out dangerous gases



Why are these air currents desirable?

sulphur, are formed in coal fires and are very unpleasant and somewhat poisonous.

Stagnant air. Dead, still air, stagnant air, is depressing. It then does not evaporate perspiration readily. Our bodies are always perspiring, even when we are at rest. The perspiration evaporates and helps to keep us from getting too hot. When it evaporates, however, it leaves behind on our skins and in our clothing waste substances that it brought out from inside our bodies. These substances add to the odor of stagnant air in closed rooms. If there is a gentle movement of air, the perspiration evaporates more easily and we feel less uncomfortable.

Let in the air. Let in the fresh air where you live and sleep. At home the windows are satisfactory ventilators. When you go to bed, open the windows top and bottom. In the rooms in which you live and work, open the window a little at top and bottom at least at intervals during the day and evening. A little opening will allow fresh air to enter at the bottom, and the heated air will go out the top. You can easily show these currents of air with a stick of smoking punk. You do not want a strong draft through



Ewing Galloway, N. Y.

Why should we maintain a good sitting position?

the room; that may chill your body so that you will take cold more easily. You want a gentle movement of air, so gentle you do not feel it but can show it with the smoking punk. In rooms where many people are assembled, as in schoolrooms and theaters, it is necessary to increase the movement of air by pumping air into the rooms or by heating air in air ducts which are led to the room.

Air-conditioning is supplying fresh, cleaned air, cleared of dust, at the proper humidity and temperature. Air-conditioning is expensive and is not necessary in homes, where there are not many people in a room. Window ventilation is sufficient in our homes.

Get the air into your lungs. If you sit in a chair with your back curved like a pretzel, a fine chance your lungs have to get plenty of air. If you go around with your shoulders sagging forward, stoop-shouldered, you are interfering with your lungs. Throw back your shoulders and "blow out your chest," as they tell the recruits in the army.

When you feel dull and stupid, stand up in front of an open window or, better still, go out of doors. Throw out your chest, swing back your arms, and breathe

deeply. Take a dozen deep breaths and see how much better you feel. Better still, play and play hard. When the muscles work, their cells oxidize food substances and demand oxygen. You breathe hard to supply the oxygen. Nature takes care of that. Give nature a chance. Get out in the sun and wind and do things, and throw back your shoulders. Do not go about rounded over like a pretzel.

How to avoid colds. Colds are due to disease germs. Usually the germs are about us. While we are strong and vigorous and not fatigued, they do us no harm. Our bodies are then able to battle the germs, and we do not get a cold. If our bodies become chilled, our resistance to germs is lowered and we may get a cold. Therefore do not get in perspiration and then allow yourself to cool off too quickly. That is especially dangerous in cold weather. Clothing wet with rain and shoes soaking wet are very likely to chill the body and so allow the germs to start to grow inside one. Therefore, use umbrellas, raincoats, and rubber overshoes. If your clothes get wet in cold weather, go home and change to dry clothes.

If you become dead tired, you are more liable to cold. Fatigue is due to the presence of poisons in your body. While the body is fighting these poisons, it has less power to fight the poisons of disease germs. Do not go where people are coughing and sneezing. A cough sends a multitude of fine drops into the air, each charged with a load of germs. If you breathe in these germ-laden droplets you risk taking cold. When you sneeze, cover your mouth with a handkerchief; do not spray the air with disease germs. If you keep the body warm, but not in a heavy perspiration, in cold weather, if you keep your clothing dry, and yourself unfatigued and in vigorous health, you probably will not take cold.

Things to Do in Learning about Good Air and Bad Air

I. Read the chapter.

II. Study about air by experiment and observation.

1. EXPERIMENT No. 36. Gather dust from the air and study it under the microscope as suggested.

2. Examine the means of heating and ventilating your schoolrooms, and, if possible, of a movie theater or other place where people assemble. How is fresh air of the proper temperature obtained and introduced into the rooms? How is room air removed?

3. Take the temperature of your schoolroom several times a day for several days. Do the same at home. Are they kept at the temperature recommended?

4. With a smoking stick of punk examine the movement of air in the room with windows and doors closed and with windows open only at the top, only at the bottom, and open top and bottom. Is fresh air moving in and used air moving out constantly?

5. If you have a hygrometer (an instrument for measuring moisture of the air) determine the humidity of the rooms. If you have no hygrometer, judge the dryness by timing the drying of a wet handkerchief and comparing with the rate of drying outdoors in the shade. Determine the rate of drying when still and when in motion.

6. Determine how the ventilation, humidity, and heating of your rooms might be improved.

7. Compare your posture with that shown in the diagram. If you do not sit, stand, and walk with a healthy posture, devise some simple exercise that will roll back your shoulders and hold up your head.

8. When you feel stupid and dull, try the experiment of breathing deeply before the open window or out of doors.

III. Test yourself by answering the following questions:

1. What is dust and where does it come from?

2. Will dust cause disease? If so, how?

3. From your collection of dust from the air, do you decide that you breathe much dust or little?

4. How does nature offer you some protection from dust and cold air? How can you take advantage of this?

5. Why do some children breathe through the mouth? How can this condition often be cured?

6. What kinds of dust in industry are especially dangerous? How can the workers be protected?

7. What should be the temperature of a living room and of a schoolroom? Are yours kept at that temperature?

8. Why should the air not be too moist nor too dry?

9. What is the advantage of gently moving air?

10. How can fires "spoil" the air?

11. How should your living room be ventilated? Your bedroom?

12. "Sit tall" and "stand tall" to show how to give your lungs a good chance to get air.

13. Tell several "common sense" things to do to avoid getting colds.

IV. Think out or investigate the answers to these questions:

1. Examine, if you have the opportunity, the heating and ventilation in houses heated with coal and oil, steam or hot water and hot air. Which system keeps the rooms nearest the best conditions of even temperature, constant change of air, proper humidity, and absence of fumes?

2. Is the air in a closed automobile or a subway train good to breathe? What can be done about it?

3. It was observed in a certain home that small articles of clothing washed at night were dry in the morning in wintertime but not in summer. Can you tell why?

4. If you have ever lived in a tent, did you provide for ventilation? How should a tent be ventilated?

5. Is a coal stove or a gas stove more likely to spoil the air in a room? Why?

V. Vocabulary. Suggestions for your list. Do not worry about words in parentheses.

spores	adenoids	relative humidity	hygrometer
mucus	tuberculosis	saturated	(silicosis)
mucous	humidity	stagnant	(aspirators)
cilia	relative	ventilation	



UNIT VII

FIRE

WHEN you go camping or go on a picnic, perhaps one of the first things you think of is a fire. When explorers meet primitive people far off in the jungles, the desert, or on the arctic shores, they note how the people make fire and how they use it to prepare food and help in other work. Explorers have never found people who did not make fires. How could we get along in civilized countries without fire? Try to think what would happen in your own home, whether in a farmhouse, a city house, or an apartment, if the fires went out and you could kindle no more. Suppose the fires of industry went out and could not be rekindled. Can you imagine what would happen to us?

Try to imagine meeting a person, perhaps from Mars, who never saw a fire. Try to tell him what fire is. Go ahead, make the attempt to tell him what fire is. Later in this unit you will find some help, but try it alone first.

Where do things go when they burn? The question sounds a trifle silly at first, but it is important in science and in industry as well as in your home. Try to answer that question too, before you read the answer in the following pages.

You know that some things take fire very easily. You hold a burning match to a piece of paper, but do not hold it near the tank of an automobile. If you do, they may pick up some charred bits of your body. You can hold a match to a piece of iron without danger, but iron will burn.

Perhaps you saw it burn in your study of the gases of the air. What makes iron burn? What makes anything burn?

We can put fire to work. Indeed we do not know how we could get the work of civilization done without fire. One of the difficulties of ancient peoples which we have largely overcome was the difficulty of getting work done otherwise than by bending the back and driving the horse, ox, or donkey. We have improved in our ability to get work done largely through increased use of fire. We have discovered ways of getting more work out of it.

But civilization will some day face the problem of finding things to burn under the boilers. We are burning up our fuels surely. When they are gone, what will do our work? When you saw a few shovelfuls of coal tossed into the furnace, did you ever stop to think that it took nature a few hundred million years to make that coal? We cannot wait around for nature to make some more. Are we wasting our resources of coal, wood, oil, and gas? When they are gone, what then will fire our boilers?

Have you seen a forest fire close at hand or a barn or farmhouse afire? There is little left when the fire has burned itself out. Was it necessary? Millions of dollars lost each year in the United States through fire could be saved. Almost all destructive fires in our cities and our country houses are due to lack of care. A great part of the forest fires also are due to carelessness. How do they start? How can fires be stopped at the start? If you were badly burned what should you do? We shall study these questions.



Globe Photos, N. Y.

CHAPTER NINETEEN

GETTING AND USING FIRE

How man got fire. Wild animals shun the fire, but men cluster around it. There was probably a time when our ancestors did not use fire, but it was a long, long time ago. Away back in the time of the great ice age when men were living in caves and hunting cave bears and mammoths for a living, they built fires. We find the remains of their fires in the caves, and near by we find the broken and burned bones of the animals that they hunted and ate.

We can only guess how man first learned to use fire, the deadly thing that sometimes swept through the forest destroying and killing. Perhaps he came upon a tree that had been set afire by lightning and was burning quietly after the storm. Chilled by the storm and the night, he found the warmth pleasant. More intelligent than the animals about him, he found that the fire could be fed and it would flourish and grow, or that it could be starved and it would weaken

and die. Our story of how man first got fire is, of course, a mere guess. It might have been from a crevice in the rock where natural gas burned night and day. It might have been from a flaming meteor that fell and set the dead wood afire. It might have been that a stone that he was chipping into an ax sent a spark flying into a bunch of dead grass.

Primitive people explained in stories or myths their guesses of the origin of the precious fire. An ancient Greek myth tells that Prometheus, one of the gods, stole the fire from Olympus, the home of the gods, and gave it to man. According to an Indian legend, the coyote stole fire and, with the aid of other animals, brought it to man.

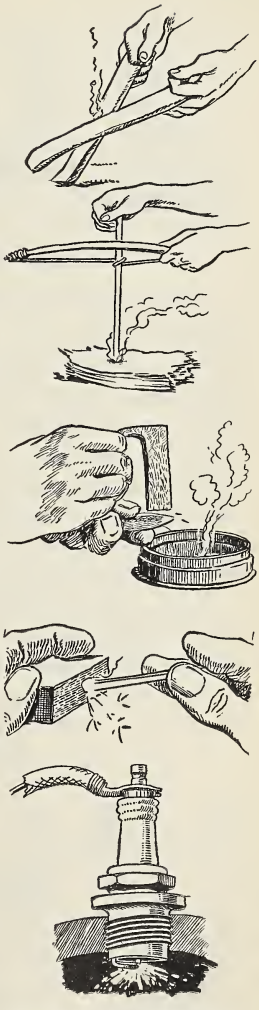
However he got fire, man cherished the thing that could protect him from cold, that could drive away the lurking terrors of the night, that could keep off the savage beasts which crept up under cover of darkness. He found, too, that cooked meats and roots were better than raw.

Fire was precious. Little wonder that it was worshipped. Little wonder that a never-failing fire was kept burning upon the altars. In ancient Rome, the vestal virgins for a thousand years kept a fire burning upon the altar in the temple of Vesta, the goddess of the household. It was at first far easier to guard the fire than to start a new one.

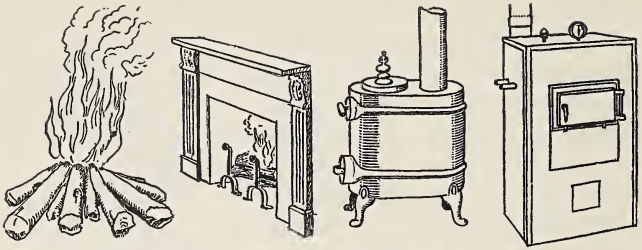
However, man learned to make fire when he wanted it. He learned to rub two sticks together until they became hot, smoked and then took fire. He fed the delicate fire with light tinder until it would burn dry twigs and bark. He learned to strike stones together and get a spark which he caught in tinder. Our pioneers in the American woods used flint and steel, and perhaps, if you are a scout, you have struck fire in the same way. It was not until 1836 that successful

matches were made. In matches we still use friction as the savage does when he rubs two sticks together, but we coat the match with phosphorus and sulphur compounds which catch fire more easily than the savage's dry sticks and tinder. We still use a spark to start the fire in automobiles and in oil heaters, but we get the spark from an electric circuit rather than by flint and steel.

Fire in civilization. Fire, perhaps, started man on his journey upward from the level of the beasts, and he continues to find more uses for it. We are still learning more convenient ways to heat our houses with fire. The open fire is cozy in the fireplaces and it has a charm in camp, but for convenience and efficiency, the stove is better even in camp. Modern furnaces give us a winter comfort unknown a hundred years ago. Fire gives the power to run our industries except where water power is cheaper. With fire we take metals from their ores. Fire melts the metals and enables us to mold them into new shapes. Fire softens the metal and enables us to hammer it into tools and machines.



Can you describe each of these ways of kindling a fire? Which are alike in principle?

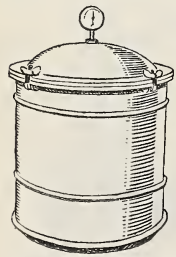


The evolution of the modern heater

By the use of fire we purify products through distillation, that is, by evaporating and condensing the vapor. By destructive distillation of coal we obtain coke, gas, ammonia, and coal tar. From coal tar, the chemist obtains many products: medicines, oils, flavors, perfumes, dyes, and other products. We obtain turpentine and rosin by distillation of juice of the pine tree, and alcohol by the distillation of fermented molasses, and by similar processes other products that we use every day in home and factory.

Fire gives us heat to kill disease germs, adding years to our health and life. It kills germs of decay, enabling us to preserve a great variety of foods in cans.

Try to imagine what would happen to our civilization if fire were suddenly lost. We would have no cooked food. We would not be warm in winter. Fires would go out under the boilers, and our industries would shut down. Railroads, automobiles, airplanes, steamships would stop. Without rapid and cheap transportation over long distances, our city populations would starve. Machinery could not be repaired, for we could get no more metal from the ores. Our metal tools would all rust



Bacteria are killed by heat in the pressure cooker

away and could not be replaced, for we could not soften the old metal to hammer it into tools. We could not melt metal to pour it into molds. Without metal tools we could cut no more boards from tree trunks to build houses. We could quarry stone only with stone tools. Without machinery on the farms, the farmers could probably produce only enough food for themselves. Most of the present population that occupies the civilized part of the earth would probably die.

Things to Do in Learning about Getting and Using Fire

I. Read the chapter.

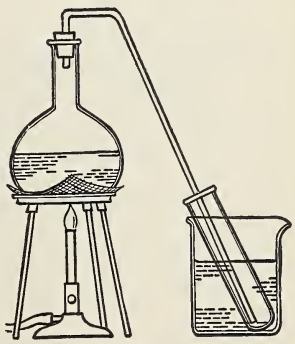
II. Study the uses of fire by experiment.

1. Try making fire without matches. If you are a scout, or if you work out the method, demonstrate it to the class. (Experiment Optional.)

2. Refer to Experiment No. 14 to call to mind how certain metals may be extracted from their ores. Examine the process further in EXPERIMENT No. 37. Mix lead oxide with powdered charcoal and heat on iron plate with Bunsen burner by directing flame against the lead oxide.

3. Demonstrate, EXPERIMENT No. 38, another use of fire in working metals. Melt solder and pour into a mold made in sand.

4. EXPERIMENT No. 39. How to distil water. Arrange apparatus as in diagram. In the flask put water colored with copper sulphate or bluing or other coloring matter, and a little salt. Clean the test tube thoroughly, for you will taste the water that distils over. Heat the flask until the steam goes over and condenses. Note color and taste of water after condensation.



A laboratory distilling apparatus

5. Experiment No. 40. Show the use of fire in preventing disease by sterilizing a tube of broth to kill bacteria. Drop a bouillon cube into hot water. When it is dissolved pour some of the bouillon into two test tubes. Plug one with cotton and sterilize it by placing in boiling water for a half hour. Let the other test tube of bouillon stand open, or when it is cooled thrust into it a stick which you have rubbed on dirty hands. Then set both aside for three days. Which tube becomes covered with a scum of bacteria or molds?

III. Test yourself by answering these questions:

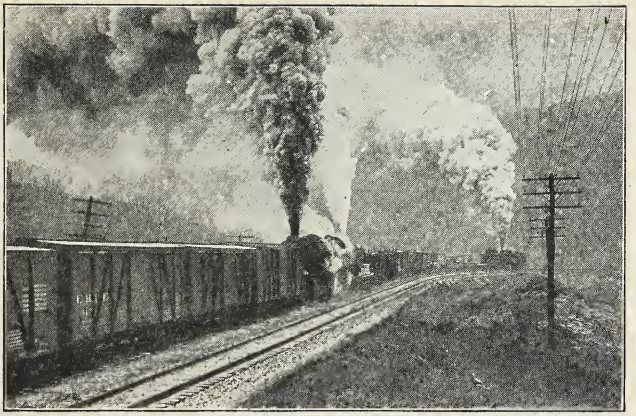
1. How can primitive man make fire without matches?
2. How in modern life do we use friction and a spark to produce fire?
3. List several uses of fire in the home and several in industry.

IV. Think out the answers to these questions:

1. When our resources of coal and oil are used up, what substitutes can we use for fuel? What substitutes can we use for fire?
2. How does an airplane use fire?

V. Vocabulary. You may know these words and so you need not add them to your list. But make sure that you know them. Be careful of spelling. Remember to put down the words which *you* have picked out. They are more valuable to you.

condensing	distillation	sterile
distil	fermented	sterilization



Ewing Galloway, N. Y.

CHAPTER TWENTY

WHAT ARE FIRE AND ENERGY?

The question. Science not only finds more and ever more uses for fire, but it has learned what fire is. Try to tell yourself what fire is. You will probably answer only that it is burning, which gives you another name for the same thing. Perhaps if you have learned something of science you will say that fire is *combustion*, but that, too, is merely a scientific name for the same thing.

Ancient Greek scientists said fire was an element. They named four elements—earth, air, fire, and water. To the modern scientist not one of these is an element. Elements were thought of as simple things that could not be taken apart into anything simpler, but which combined to make everything else. The modern scientist has taken apart three of the ancient elements—earth, air, and water, and he has shown that fire is not a "thing," not substance or "matter." Let us try to see what fire is.

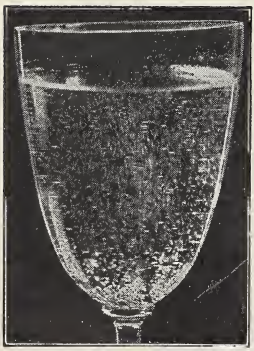
Burning makes new substances. Let us go back to burning charcoal. Charcoal is largely a

substance called *carbon*. You have no doubt heard of carbon in the automobile engine. You have seen soot about a chimney or a lamp chimney. If you have not seen soot, hold a white dish in a candle flame. The black stuff that forms on the plate is soot, almost pure carbon. Graphite, a black substance which you may have seen used as a lubricant, is carbon. Coal and coke are largely carbon. Another form of carbon is very different; it is the diamond.

If you let the water from the faucet run on the black deposit on the white plate, you find that carbon does not dissolve in water. If you have gotten it on your hands around an automobile, you have found that it does not dissolve in soapy water.

You have learned that carbon unites very readily with oxygen and forms a new compound, carbon dioxide. You have met carbon dioxide in soda, ginger ale or "pop." They "pop" and fizz because carbon dioxide is escaping. Dry ice is solid carbon dioxide.

Other things burning in oxygen also make new substances. You have learned that sulphur forms sulphur oxide, phosphorus forms phosphorus oxide, iron forms iron oxide. Oxygen always joins with something else to form a new substance. This union of oxygen with something else is called *oxidation*. When wood, coal, oil, gasoline, or gas burns, there are several new substances formed by oxidation. Carbon is in all these things, and on burning forms carbon dioxide.



Sally Pepper, Phila.

The bubbles in your ginger ale are carbon dioxide

Hydrogen is also present in fuels. Perhaps you have heard of it. It is a very light gas.

Therefore it is sometimes used in balloons, but it is dangerous, being very explosive. That is, it unites with oxygen very easily and very violently. It is used with oxygen in blow torches in welding pieces of iron together, because it burns with a very hot flame. When hydrogen oxidizes, it forms an oxide of hydrogen. This oxide of hydrogen is water.

When any of the common fuels burn, they produce water as well as carbon dioxide. You can show that water is formed when gas or a candle burns, by holding a cold plate or a cold piece of iron in the flame. You will see in just a moment a little film of moisture gather on the cold object. In another moment when the plate or iron becomes heated the moisture evaporates.

When the union with oxygen is so violent that there is heat and flame, we call it *burning*.

What are fire and flame? It is fun to try to say exactly what you mean and to find out exactly what you mean. What is fire? What is burning? What is flame? By a series of experiments you have studied what burning is. You have learned that it is the union of oxygen with an inflammable substance (substance that will burn); a chemical action. Sometimes oxygen unites with another substance very slowly and we do not say that it is burning, for example in the rusting of iron. We say that it is burning when the union is accompanied with heat and flame.

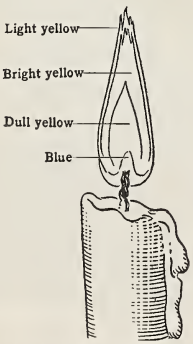
Try to say what flame is. You will need to try another experiment to define flame. (Experiment No. 43.) You need very little apparatus, a candle, a few matches, a white plate and a glass or metal tube about six inches long. Light the candle and look at the flame. You have often seen a candle flame, perhaps, but did you ever look at it—scientifically, really

examine it? You notice the bright yellow part first. At the outer edge of this bright part the color shades off to a less bright part, a fainter envelope, over the flame. In the center of the flame the yellow part is also duller. Down at the base it is blue.

Lower a white plate into the bright yellow flame. You find black stuff deposited on the white plate. You will probably guess that the black stuff is carbon. In the candle flame are solid particles of carbon. In the heat of the burning candle, the carbon particles become so hot that they glow and give the light of the candle. In the outer envelope of the flame, the carbon is burned to carbon dioxide.

Now take the tube and hold the end in the duller inner part of the flame just above the top of the wick. If you hold a lighted match at the outer end of the tube, a flame appears there. A gas is passing from the inner part of the flame and burning at the end of the tube like the flame in the gas burner. The burning candle makes gas out of the candle grease. The *flame* is the burning of a gas.

Now we have defined burning and flame. Try to say what fire is.



Parts of a candle flame

Kindling temperatures. You saw that oxygen of the air would unite with iron if only a little water were present. It needs a little encouragement but not much. With pure oxygen, iron united vigorously if it got considerable encouragement by heating to a high temperature and starting with burning sulphur. Oxygen of the air unites with carbon. Charcoal burns with a low flame. In pure



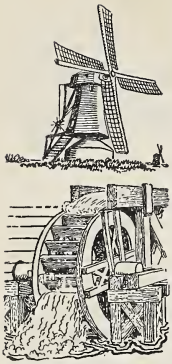
Drawing gas from a candle flame

oxygen the flame is brilliant, but it has to be kindled by heating. Sulphur unites more readily with oxygen; it takes fire easily. Phosphorus is so greedy for oxygen that in the laboratory it is kept in a bottle of water. If you lay a piece of phosphorus on the table, the phosphorus will take fire without holding a match near it, as soon as the water dries. Each substance must be heated to its kindling temperature before it takes fire, and phosphorus takes fire at ordinary temperatures.

Did you ever start a coal fire? No? Well you cannot start it with paper. The paper burns out too fast to light the coal although it may be hot enough for a short time. You can start wood burning with paper. If you shave the wood into fine splinters, as you do in camp when you have no kindling paper, you can light the wood with a match. Small pieces of coal, or coal dust, take fire so easily that violent



How to lay a fire

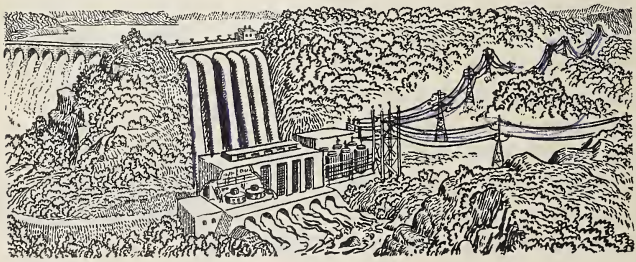


Wind and water may work for us

explosions are sometimes caused. The size of the combustible material (material that will burn), as well as the temperature determines when burning occurs.

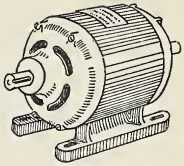
The ability to work. When we burn coal or oil under the boiler of a steam engine, the engine will do work. It will draw a train, propel a steamship, run machinery in a factory, turn a dynamo to generate electricity, or do other things. The capacity to do work comes from the oxidation of the fuel. The oxidation gives heat. In heat lies the capacity to do work. We find the capacity to do work elsewhere. We find it in water that is moving downhill. We find it in air that is moving as wind. We find it in the heat of the sun, although we do not now harness the heat of the sun and make it run engines for us.

Now let us use one scientific word for the phrase, "the capacity to do work." The word is *energy*. The scientist says: Energy is the capacity to do work. Oxidation of fuel gives us energy. Water flowing downhill gives us energy. Wind gives us energy.



How is one form of energy being changed to another?

The energy that we get from fuel is heat. Heat is a form of energy. The energy that we get from wind and water is the energy of motion. The energy we get from a dynamo is electric energy.



We can turn one kind of energy into another kind. In the steam engine we turn the energy of heat into the energy of motion. In the dynamo we turn the energy of motion into electric energy. Then we can turn the electric energy into energy of motion again, as in the trolley car or electric engine. We can turn it into heat as in the electric stove or into light energy as in the electric bulb.



Tell how each picture illustrates change in the form of energy

We shall use the word *energy* often. Remember that energy enables us to do work. Most of the world's work today is done by the energy that comes from oxidation. Oxidation gives us another kind of energy, light. We oxidize candle grease in the candle or oil in the lamp to get light energy.

We must get the energy from somewhere; we cannot make it out of nothing. We get it from oxidation of fuels, from moving wind, or from moving water.



In how many and in what ways is this energy used?

We get it from our environment. Always we get it from somewhere. We cannot create energy.

Things to Do in Learning What Fire and Energy Are

I. Read the chapter.

II. Study fire and energy by experiment.

1. EXPERIMENT No. 41. Collect some carbon on a dish as instructed on page 200. (1) Find out what it looks like and whether it will dissolve in water or any other common liquid.

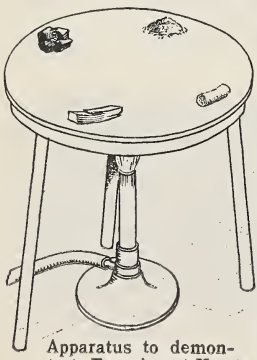
2. Make some carbon dioxide from charcoal or wood and prove that you have made it by testing with limewater. Or you may refer back to your report on Experiment No. 30.

3. EXPERIMENT No. 42. Show that water is formed when gas or a candle burns. Refer to page 201. Write a report of your experiment, using the usual headings.

4. Perform EXPERIMENT No. 43 as directed on page 201 to learn what a flame is.

5. EXPERIMENT No. 44. Do all substances take fire at the same temperature? Place a metal sheet on a tripod and on it place the substances coal, wood, sulphur, a match head at equal distances from the center. Heat the center of the sheet with a Bunsen burner. Write a report in the usual form.

6. EXPERIMENT No. 45. Think out a method of using fire to turn one kind of energy into another kind of energy, and demonstrate it.



Apparatus to demonstrate Experiment No. 44

7. EXPERIMENT No. 46. If you have a small steam engine or small motor or dynamo or any one of the various household electrical appliances, you can turn one kind of energy into another. Think how you can show it, and then demonstrate. If you have none of these machines, you can still think out a method of turning one kind of energy into another.

III. Test yourself by answering the following questions:

1. What new substance is formed when charcoal burns?

2. What new substances were formed when the candle or gas flame burned in Experiment No. 30?

3. Burning is a union of fuel with some other substance. What other substance?

4. Can you name a substance that has a low kindling temperature? Is it a safe substance to store? How can it be stored? Name a substance that has a high kindling temperature.

5. When you build a fire out doors or at home, how do you show that the size of the combustible material has some effect on kindling?

6. What is the scientific word for capacity to do work?

7. How does fire enable man to do more work?

8. Mention a case in which man uses fire to turn one kind of energy into another?

9. Mention three different ways in which man gets energy from his environment.

IV. Think out the answers to these questions:

1. By what process do you get the energy in your body that enables you to do work?

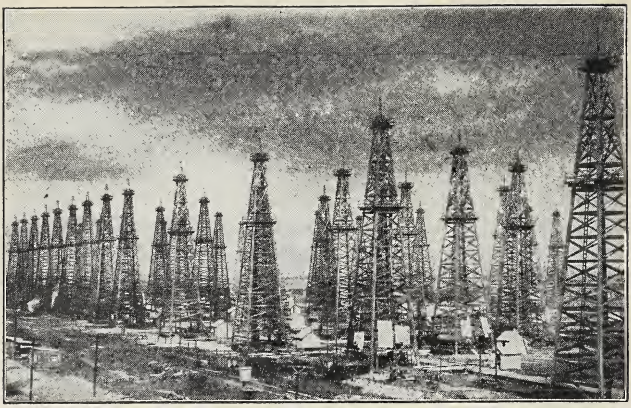
2. Is it safe to have substances of low kindling temperatures around the house? Mention one such substance sometimes found around homes. What precautions should be taken in handling it?

3. There is energy of motion in the winds. Can it be put to work? There is energy of motion in the tides and waves of the ocean. Have you heard of any plan to put this energy to work?

4. There is energy coming to us from the sun. What kind of energy? Do you know of any scheme to put it to work?

V. Vocabulary. Suggestions for your list:

combustion	matter	energy	fire
oxidation	element	flame	



Ewing Galloway, N. Y.

CHAPTER TWENTY-ONE

FUELS

Common fuels. All our fuels were once parts of animals or plants. Our common fuels are either solids, like wood, coal, and coke; liquids, like oil and gasoline; or gases, like gas from the gas works or natural gas from gas wells. Coal is the partly decayed remains of plants that grew in the long-past history of the earth. The coal forests, with their beds of dead leaves and roots and stems, were covered over with layers of mud and sand which changed into rock. The plant remains themselves became a kind of rock which we call *coal*. We are not certain what changed into oil, but are sure that it was the remains of plants or animals or both. The dead bodies have disappeared but part of their substance has become oil. Oil is found under layers of rock from which it is obtained by drilling. Natural gas often collects above the oil, so that oil regions are often gas regions.

Science, as usual, improving on nature, prepares some artificial fuels from the natural fuels or other substances. Often these artificial fuels are much

better than the natural fuels for certain purposes. Thus coke is much better than coal for use in getting iron out of the iron ore. Coke is made by heating coal in closed ovens and driving off gas, which is used for other purposes. The coke prepared for iron is not the coke sometimes used in our homes. It is too hard and does not take fire easily in our stoves. In the gas works of our cities, gas is driven off from the coal and stored in great tanks to be led through pipes to the houses. When the gas is given off, coke is left behind and may be used as fuel in the home.

In most of the country homes, the fuel is wood, because it can be easily obtained. Other fuels cost so much more that they cannot be used in many parts of the country. Wood is not the most efficient fuel. If you have used a wood fire at home or in camp you know that you may get a very hot fire, so that the handle of the frying pan will burn you badly if you touch it with your bare hand. A disadvantage of wood is that it burns rapidly. In camp if you sleep by the fire you must get up during the night to put on more wood. In the farmhouse you light a new fire for breakfast.

Pound for pound, coal gives far more heat than wood. Soft, or bituminous, coal gives more heat from a pound than does hard coal, or anthracite, but the smoke from soft coal is not pleasant, and soft coal must be put on the fire more often. A pound of coke gives

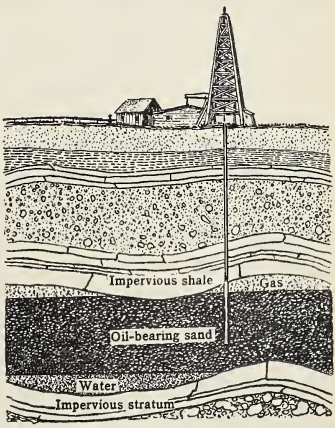


Diagram of an oil well



H. Armstrong Roberts, Phila.
Cutting wood for fuel

almost as much heat as a pound of coal. Coke catches fire readily and burns rapidly. It gives a quick, hot fire, but needs more attention than coal for it burns out more quickly. Gas gives less heat than coal, but it is so convenient that, where it can be had, it is usually the fuel for cooking. For house heating, gas is often used but is usually more expensive than oil or coal. For efficiency, oil is the best fuel. A pound of oil gives more heat than a pound of other common fuels, but it costs more than coal and is less convenient than gas.

When the gas stove burns yellow. Did you ever notice the gas burner in the kitchen stove burning with a yellow flame or giving off a bad odor? The yellow flame is not as hot as the blue flame and blackens the pots. You usually can remedy the defect very easily. The gas passing into the burner is mixed with air. You can see that very easily in the Bunsen burner used in the laboratory. When you close the air holes at the bottom of the Bunsen burner, the flame is yellow. When you let in the air, the flame is blue. The yellow flame is due to particles of carbon. They become very hot and give off a yellow light. You can easily see the carbon by lowering a white plate into the yellow flame. The black deposit on the plate is carbon. In the yellow flame the carbon does not get enough oxygen to burn completely. If you let in more air the carbon burns completely. When you have a yellow, smoky flame in the kitchen gas stove, examine the holes near the turncock to

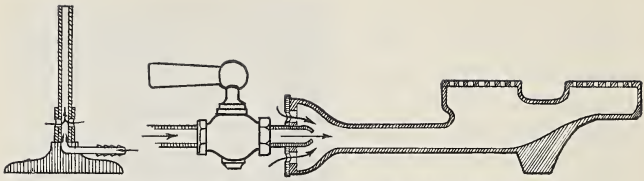
see if they have become clogged or closed. After cleaning the holes, adjust the opening until you get a good, blue flame When you find a bad odor from the stove see if the flame is burning back in the burner at the air holes. If so, take off the burner (it usually lifts off), clean it out with a wire so that the gas flows freely, adjust the air holes, and the trouble will probably be corrected.



Philip D. Gendreau, N. Y.
Mining coal

When the coal on the earth is all burned. Coal runs our industry, and we are burning it rapidly. A day is coming when there will be no more coal available on earth. Then what will keep people warm and furnish power? We do not know. Oil will be exhausted long before the coal. And we are using wood seven times as fast as it will grow. What shall we do when coal, wood, and oil are gone? There have been several schemes suggested: wind power, water power, sun power. All together with the best machines that we have today, these three sources of power would not give us nearly enough heat and power. We have been wasting coal, oil, natural gas, and wood. In spite of all we can save by stopping waste, these fuels will some day be used up. We do not know what will happen then, but we want to postpone the day of exhaustion. We must stop the waste.

We get fuel from the things around us, from our environment. We cannot use oxidation to run our engines unless we find something around us to oxidize. We must find everything on the earth about us or we



Compare the Bunsen burner and the gas stove

must find the raw materials from which to make the things we use. What we do depends upon what we find about us. If we find nothing to burn, we cannot run our machinery by oxidation. If we find no water power, we cannot run our machinery by water power. Our environment must supply us.

Things to Do in Learning about Fuels

I. Read the chapter.

II. Study fuels by experiment and observation.

1. Make a collection of fuels for the school museum.

2. In Experiment No. 44 you found out something about the kindling temperatures of several substances, some of which are common fuels. You might add coke to the list by further experiment, and also compare soft wood, hard wood, and paper. Call this extension Experiment No. 47.

3. Experiment No. 48. To show how gas is manufactured. Arrange apparatus as in the diagram on the facing page. Place a little soft coal in the upper test tube. Brush the tube with the flame of a Bunsen burner to heat gently. After heating the tube for some time, light the gas coming from the small tube as shown on page 213.

4. Experiment No. 49. Study the Bunsen burner in the laboratory and the burner of the gas stove at home. Try opening and closing the air passages at the base of the burner. Light the gas at the holes at the base of the burner and notice the color of the flame and the odor. You learned that the black is carbon and that carbon burns with a yellow flame. Remember these things when the burner in the kitchen smells badly or burns yellow. Hold

a white plate in the yellow flame and examine the plate. Then clean out the holes at the base of the burner.

5. EXPERIMENT No. 50. Determine which flame, yellow or blue, takes longer to bring the same quantity of water to boiling temperature.

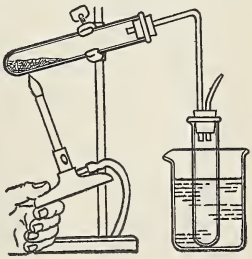
Write reports of these experiments in the usual form.

III. Test yourself with the following questions:

1. How did coal originate?
2. How does coke originate?
3. How is gas made?
4. Write in two columns the advantages and disadvantages of each of our common fuels. What fuel do you use at home? Why? What fuel is used in your school? Why?
5. What is the advantage and the disadvantage of the yellow gas flame? Why is the flame yellow? How can it be changed to blue?

IV. Think out the answers to the questions:

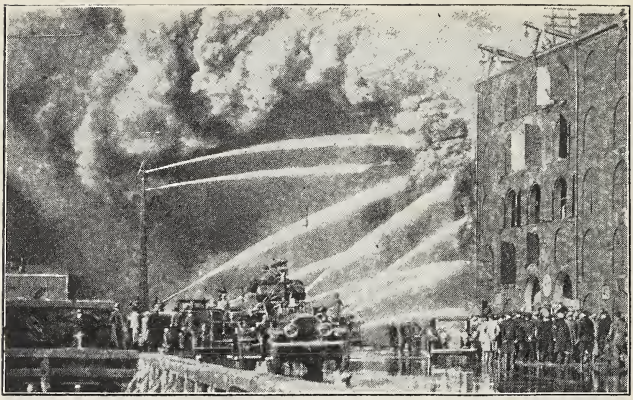
1. Why is the flame yellow in an oil lamp? How can it be made blue?
2. In the last paragraph of the chapter, it is stated that we must get our fuel from our environment. Does anything come to us from away beyond the earth? Can we get heat from it when our coal and oil are used up?
3. We can make great supplies of alcohol. Could it be used for cooking? You might find out by experiment. Think it out and talk it over with your teacher before you experiment. Then write a report of the experiment, call it EXPERIMENT No. 48A. Draw conclusions as to its advantage and disadvantage as a fuel for cooking.



Making illuminating gas from coal

V. Vocabulary. Suggestions. Remember to make your own list.

coke bituminous anthracite carbon peat



Ewing Galloway, N. Y.

CHAPTER TWENTY-TWO

DESTRUCTION BY FIRE

Destruction by fire. Four or five hundred million dollars worth of property are lost each year in the United States through fire. In addition, lives are lost. This can be stopped. It is almost all due to carelessness. Cigarettes tossed into paper, oily rags, or dry leaves start many fires. Forest fires often start beside the road, just where cigarettes have been thrown from a car. Those fires can be stopped before they start. A lighted cigarette should never be thrown away. It should be put out first. Sometimes one sees beside a road through the woods, a sign erected by forest officers warning all persons not to smoke while walking through the woods. Another cause of forest fires is campfires. Campers sometimes leave a fire burning when they go away. Every campfire should be soaked with water before it is left.

Electricity is a common cause of fires in homes. Most electric irons get constantly hotter as long as the current is turned on. If left on the ironing board and forgotten, an iron will surely set fire to the ironing

board. The better grade irons are equipped with safety devices which shut off the current when a certain temperature is reached. Never leave an electric iron, toaster, or other electric device without disconnecting it. Watch the cords of irons and lamps. If their insulation becomes worn, a short circuit may set fire to the house. Replace every worn cord promptly.



H. Armstrong Roberts, Phila.

The good camper always puts out his fire

Oily rags will sometimes catch fire from slow oxidation which gradually warms them. Always put oily rags into a covered metal can until burned or buried.

Piles of waste paper in the cellar with the furnace are dangerous. Sometimes a slight explosion in the coal or oil will blow open the door and scatter a few sparks. If no paper, dry wood, or other combustible material is around, probably no harm will be done. If a spark strikes some combustible material, the house may be destroyed. Hot ashes dumped into wooden barrels have started fires. They should be placed in a metal can and covered with a metal lid. Deposits of soot in chimneys sometimes become hot



Three common causes of fires



Ewing Galloway, N. Y.

Fire drills have saved many lives

and take fire. Chimneys should be cleaned, especially when soft coal is used.

In case of fire. What would you do if a fire started in your home? in your school? in the movie theater? You should know before the thing happens. If you know ahead of time, you are less likely to lose your head and suffer harm. First decide beforehand how you would get out quickly if necessary. Locate fire escapes, doors, and stairways, and windows close to the ground. In schools there have been hundreds of deaths when there was no fire drill or when the drill failed in a fire. See that the drill never fails. When the gong rings you do not know whether there is a fire or not. Fires occur. Do your part exactly as you have been trained. Lives may depend upon it.

The next important thing in case of fire is to know how to get help. Locate the fire-alarm box and know how to send in an alarm. If a telephone is at hand, pick it up and say to the operator, "I want to report a fire." The telephone companies have instructed their operators to send the message to the right place immediately.

If the fire is just starting, a blazing wastepaper basket or a curtain on fire, put it out. Throw a cupful of water on it, or smother it with a rug. If your clothing catches fire, lie down immediately. Keep the fire away from your head, do not breathe the flames. Do not run; that fans the flames. If you can, pull a rug or coat over you to smother the flames. If there is no rug, roll on the flames. Pull off the flaming clothing.

Grass fires often start from bonfires or from sparks from trash burners. Unless the grass or bushes are tall, such fires may often be beaten out with a shovel or a broom. The strokes of the shovel cut off the supply of oxygen long enough to put out the flames.

If your flesh is burned. If you burn your hand slightly, a little oil poured on it will relieve the pain. Olive oil, vaseline, mineral oil, or any oil without salt will do. If you are severely burned, you must have a doctor. Failure to see a doctor may mean permanent injury or loss of use of a limb or severe and prolonged illness. While the doctor is coming, treat the burn with oil and keep quiet.

Fire extinguishers. Water is a good fire extinguisher, but never use it on an oil fire or gasoline fire. Then use sand or dirt if no fire extinguisher is handy. Oil and gasoline are lighter than water and float on top of water carrying the fire with them. There are several common kinds of fire extinguishers. One is worked with a handle which is pumped in and out. This throws a small stream of liquid on the fire. The liquid is carbon tetrachloride. This liquid immediately turns to a gas which is heavier than air and drives away the air, thereby shutting out the oxygen and putting out the fire. Carbon tetrachloride is sometimes put up in bottles which may be broken in the fire.

The second type of fire extinguisher has a bottle of sulphuric acid in the lower end, and contains a solution of soda. You carry the extinguisher to the fire, then turn it upside down. The acid mixes with the soda and produces carbon dioxide. So much carbon dioxide is produced that the pressure of the gas forces the liquid and gas out through the nozzle in a stream which may be directed on the fire.

"Fire foam" is made from a mixture of licorice root and aluminum compounds with carbon dioxide. It is directed on the fire and immediately forms a tough foam which shuts out the air and stops the fire. It is especially valuable in fighting oil fires.

Another form of apparatus is a tank containing carbon dioxide under great pressure. The pressure condenses the carbon dioxide to a liquid. When the valve of the tank is opened the pressure is released and the liquid carbon dioxide changes to the gas. The very rapid evaporation of some of the liquid carbon dioxide cools the rest of it so low that it changes to a solid, carbon dioxide snow, or dry ice. The snow, or dry ice, turned over the fire quickly puts it out. This is especially valuable in an oil fire.



Three popular types of fire extinguishers

After a fire extinguisher is used, it should be immediately refilled and hung in its usual place. Always keep the fire extinguisher in the same place and always ready for immediate use.

Things to Do in Learning about Destruction by Fire

I. Read the chapter.

II. Study fire prevention by observation and experiment.

1. Search your home and school, noting "fire hazards" such as those mentioned in the chapter.

2. Remove these hazards or make recommendations to give to those in authority.

3. Search all lamp cords and electric wires in your home for possibilities of fire. Then do something about it. Remove the fire hazard.

4. In the home, your school, your movie theater locate the fire exits and decide how you would get out in case of fire. Learn exactly what you are to do in the school fire drill and do it.

5. Locate the fire alarm nearest to your home or school and learn how to send in an alarm. Also locate the nearest telephone that you can reach quickly.

6. Locate the fire extinguisher in your school and learn how it is operated. If you have one in your home, learn exactly where it should be kept to be handy in case of need, and keep it there, charged, ready for use. If you have no fire extinguisher, decide what you would do in case a curtain or a wastepaper basket caught fire.

7. EXPERIMENT No. 51. Make a small fire extinguisher. Get a wide-mouth bottle with a good cork and a test tube that will go inside the bottle. Bore a hole in the cork and push a glass tube through the hole. Half fill the bottle with a solution of baking soda. Half fill the test tube with dilute hydrochloric acid. Lower the test tube into the bottle carefully so the acid does not spill. Cork the bottle and tie in the cork. Start a fire with a few small pieces of paper in a tin pan. Turn the fire extinguisher upside down and point the tube on the fire. Do not get the solution on

your clothes, for it will leave spots. Write a report of this experiment under the usual headings.

8. Experiment No. 52. Drop half a teaspoonful of carbon tetrachloride (carbona) on a small fire as in the last experiment. Write the report.

III. Test yourself by answering the following questions:

1. List the ways in which fires start in homes, schools, and in the forest. Decide, if possible, how each one of these ways could be eliminated.

2. How does electricity start fires? What steps would you take to prevent fires starting from electricity?

3. What would you do if fire started in your home? in your school? in your movie theater?

4. How would you get help immediately in case of fire at home? at school?

5. What should you do in fire drill in your school?

6. What would you do if your clothes caught fire?

7. What two things should you do if you were severely burned?

8. Tell the principle of the different kinds of fire extinguishers and how you would operate each kind.

IV. Think out or investigate these questions:

1. Gasoline is sometimes used for cleaning clothes. It is very dangerous. What can you use instead, with no danger from fire?

2. How can you build a campfire or picnic fire that is safe?

3. It is unsafe to use kerosene when starting a fire in the stove. What is safe and a quick way to light the fire?

4. Why does smothering a fire put it out? Why does sand put out a fire? Why does water put out a fire?

V. Vocabulary. Did you find any words for your word list?

insulation combustible



UNIT VIII

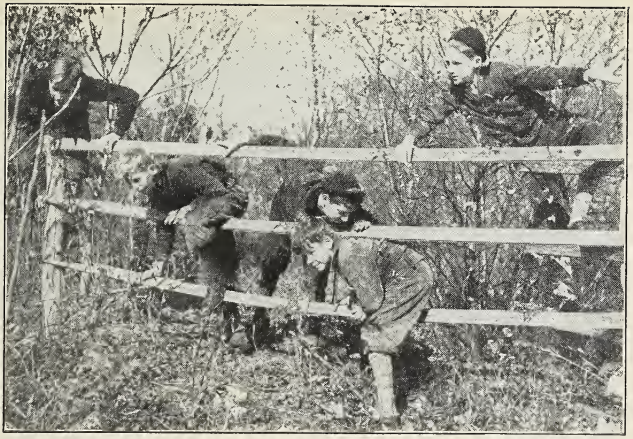
HEALTH

SUPPOSE you bought an automobile. You filled it up with gasoline, and started going. You stepped on the gas uphill and downhill, over rough back roads, around curves, against curbstones, and over bumps in the road. When the gas ran low, you filled up again with the first gas that came handy. You paid no attention to lubrication or to squeaks, rattles, and knocks. You did not bother with the battery or with headlights or taillights. You just ran it for all that it was worth. How long would your automobile run?

Your body is not an automobile, but you can run it for all it is worth. You can fill up the stomach with the first tasty thing that comes handy. You can neglect to put in water except when you are hot and thirsty. You can go at top speed and give it no rest. You can neglect the little pains and aches and fatigue. You can for a time, and then the breakdown comes as surely as in an automobile that is abused. Of course your body is, to a large extent, self-repairing if you provide it with the repair material. Any kind of food stuffed into the stomach will not do for repairs or for growth. Selecting the proper materials to keep your body properly running, self-lubricating, and self-repairing requires a knowledge of what kind of materials are needed for lubricating, speeding up and slowing down and repairing the body, and for growth. This is an exceedingly complex study, but the general principles can be easily understood and put into practice. Your body needs other

care: cleaning, removing refuse, rest, work, and play. Just how and how much of each?

You admire the boy or girl who can hike all day, who can swim, skate, and play tennis, who can do a heavy day's work in the hayfield or the woods or about the house without getting fagged out. You admire the athlete and the worker "who can take it with a smile." It is a matter of health. Unless you have some bodily parts that are "made wrong," you can develop a superb body that is just bubbling over with health. It is a matter of knowing what to do and then developing the will power to do it. In this unit we shall try to supply what you ought to know, but it is "up to you" to supply the will power.



Ewing Galloway, N. Y.

CHAPTER TWENTY-THREE

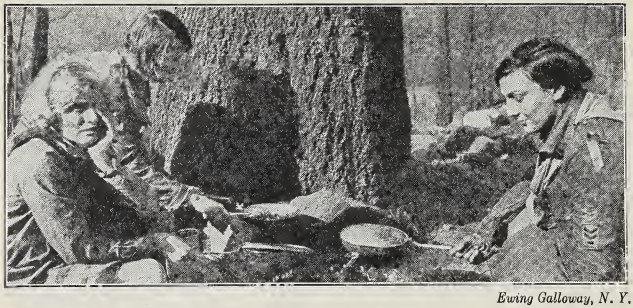
ENERGY TO LIVE

Work and warmth. If you hurry upstairs or uphill, you know that you are working. If it is in summer, you are well aware that some heat was generated in the work. Even on a cold winter day, brisk walking warms you. Work and heat have some connection.

Even if you are not walking or doing other work, your body is warm. Your temperature is 98.6° F., winter and summer, indoors and out. Heat is generated in your body as long as you are alive.

As long as you are alive, also, parts of your body are in motion. Your heart is beating, and you are breathing air in and out. Muscles are moving inside your body when you have no knowledge of it. The muscles that move the walls of your stomach and intestines go on with their work without your taking thought.

Even the cells in your body that do not move are using energy. It takes energy to keep alive. In life



Ewing Galloway, N. Y.

Fresh air and exercise demand plenty of food

there is always heat and there are always changes going on.

Your body's work takes energy. Just to live, your body must find energy. It cannot make energy. Just as in industry, the energy must come from things around it, from the environment. Energy in the body is generated as it is in the steam locomotive. The chief source of energy is oxidation. Things are oxidized inside you to produce the energy for life and work; coal is oxidized in the furnace of a locomotive to produce the energy of motion.

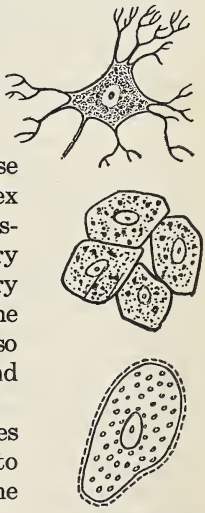
Oxidation requires oxygen and fuel. You know that the body gets its oxygen from the air that it breathes in. It gets its fuel from the food that is eaten. Oxygen and food are the raw materials for oxidation within the body.

The body's oxidation is not as rapid as oxidation in the steam locomotive. There is no flame and fire. But there is heat. While life lasts, heat lasts. There may be very little heat as indicated by the thermometer. The fish, frozen in the ice to revive again when thawed, is almost the temperature of the ice, but extremely slow oxidation still goes on. If it fails, the fish dies.

With the heat there is other energy, the energy of motion and electricity. The electricity is small in amount compared with the current that runs into our houses from the wires along the street, but it can be measured. It has been measured in a working muscle and in a nerve, even in the brain.

Firing the body's furnaces. The furnaces of the body in which the oxidation takes place are the cells that make up the body. Below are shown some of them. The living substance inside of these cells is called *protoplasm*. As long as it is alive, protoplasm is carrying on oxidation. The cells buried deep in the body must be continually supplied with both air and food.

Just as in the furnace, oxidation in the cells produces carbon dioxide and water. Other products of oxidation are also formed. Just as in the furnace, all products of oxidation must be taken away, or they will put out the fire.



Nerve, cartilage, and liver cells

The body, therefore, must have means of getting food and oxygen and of getting rid of the waste. These services are carried on by complex systems of organs. The digestive system prepares food, the respiratory system gets oxygen, the circulatory system delivers fuel and oxygen to the cells. The circulatory system also takes away refuse to lungs, skin, and kidneys which cast them out.

Other kinds of cells form muscles which move the body from place to place and move the parts within the body, such as the heart and the breathing and digestive organs. Another



Ewing Galloway, N. Y.

A clinical thermometer is used to measure body temperature

system, the bones, work with the muscles to move the body around and to hold it in position so that its parts can carry on their work. Still another system of cells, the nervous system, control the workings of the body as a whole and of its various parts. All the various kinds of cells work together to serve the body, to keep alive. All cells are helping one another to live. Life lies in the cells of all kinds. It is inside the cells that the vital work of oxidation goes on.

Things to Do in Learning about the Energy to Live

I. Read the chapter.

II. Study your own body.

1. Take your temperature either with a clinical (doctor's) thermometer or a laboratory thermometer. Look at the clinical thermometer above. You will see a little curve in the column of mercury at the bulb due to a curve in the bore of the tube. This curve prevents the mercury from running back into the bulb until you have read it. Shake the thermometer until the mercury is well down the tube. Do not jar it or you may break the glass. Place the thermometer under the tongue as the doctor does. Keep it there a few minutes. Then remove it and read it. If you use a laboratory thermometer have a classmate read it while it is still under the tongue for it will start to fall as soon as you remove it from the mouth. What is your temperature?

2. Exercise briskly and take your temperature again. Does exercise raise the temperature? Account for the result.

3. Sometimes you probably have felt warm immediately after eating. Take your temperature after eating. Account for the result.

4. If you have a microscope available, scrape gently the inside of your cheek and mount the cells on a slide for examination under the microscope.

5. Locate in the diagrams the digestive, respiratory, and circulatory systems.

III. Test yourself by answering the following questions:

1. How can you show that heat is being generated in your body?

2. What is the temperature of the healthy human body?

3. What work is constantly going on inside your body?

4. How can you show that muscular action makes heat?

5. How can you show that just staying alive makes heat?

6. What raw materials does the body need to make heat?

7. What energy is generated in your body in addition to heat?

8. In what structures in your body is the heat produced?

9. By what process in the body is heat generated?

10. When heat is generated, what waste products are produced?

11. Write down a list of the systems of organs in the body and tell the general work of each.

IV. Think out the answers to these questions:

1. What is a fever and why does it develop?

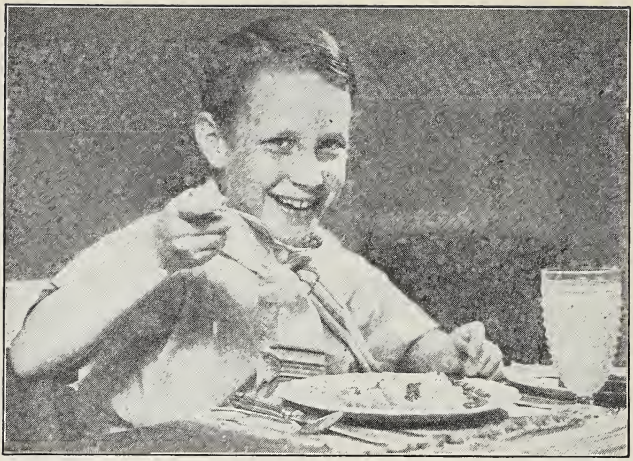
2. Does a snake need as much energy in summer as in winter? What are your reasons?

3. Would you expect a bird to have the same temperature as a man? What are your reasons? Would you expect a bird to eat the same amount of food in proportion to its body weight as a man does?

4. Compare the living body to an electrical power plant. Name for each: the raw materials taken in; how energy is generated; what kind of energy; what becomes of it.

V. Vocabulary. You may know some of these words. Add the new words to your own list.

generate energy protoplasm



Bobbitt, N. Y.

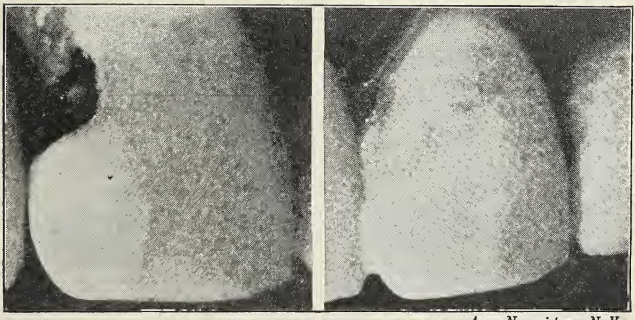
CHAPTER TWENTY-FOUR

PREPARING THE FOOD TO GO AROUND THE BODY

Why preparation is necessary. Beefsteak and potatoes cannot feed the fires of life, nor can other foods except, perhaps, grape sugar. Food as we get it could never reach the cells of the body. A piece of potato or a piece of beefsteak could not flow through the blood vessels. Even the cells that line the mouth and stomach could not take in the beefsteak and potatoes through their walls.

Before food begins its journey through the body it is made ready by digestion. In this process the food is changed to a liquid. Potatoes, beefsteak, bread, candy, and pretzels are all changed into liquids that can be absorbed by the cells of the digestive system and sent into the blood.

Choppers and grinders. The first step in digesting beefsteak and potatoes is breaking them up into small pieces. The teeth do this work. The teeth



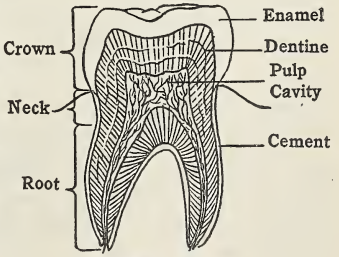
Acme Newspictures, N. Y.

A tooth cavity. The same cavity filled.

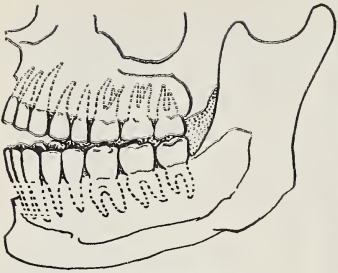
cut off small pieces, if we give them a chance. They then tear, crush, and grind the pieces until the food is a mass of wet pulp—if we give them a chance. Teeth are wonderfully efficient machines, if they are sound and properly placed and if they are taken care of. They are inefficient, painful, and dangerous, if they are not taken care of.

The teeth must be well arranged in the mouth to do their work. Sometimes they grow in "out of alignment" like the wheels of an automobile that have hit a rock. Often the dentist can straighten these poorly directed teeth, provided he gets the patient when the teeth are young. Therefore, it is important that children's teeth be examined frequently by the dentist.

Sometimes parents neglect the first teeth because they will be lost later. Unfortunately, if the first teeth are poorly arranged and do not come in properly, the jaw may become misshapen and the permanent teeth will also be poorly



Parts of a tooth



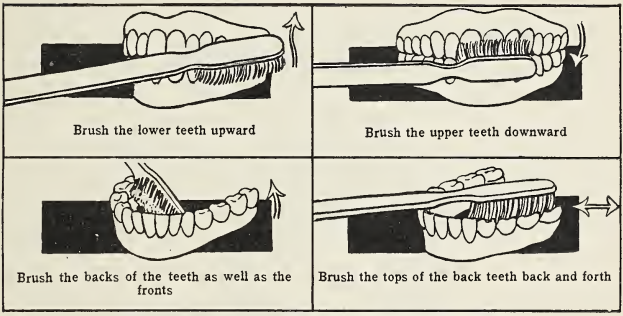
The human teeth

arranged. Often, also, the first permanent *molars*, the "back" teeth, come in when the child is about six years old. If these molars decay, they will never be replaced.

How a tooth is built is shown on page 229. The *pulp cavity* is alive, containing blood vessels and nerves. A small opening at the bottom of the root admits the nerves and vessels. The bulk of the tooth is made up of *dentine*. The *crown* of the tooth, the part that projects above the gums, is covered with an extremely hard substance called *enamel*. The part below the gum line is covered with a softer cement.

Taking care of the teeth. If decay exposes the softer parts below the enamel the tooth soon hurts and it cannot do its work. In addition disease germs may grow and poison the whole body. Therefore, beginning cavities in the tooth must be discovered, cleaned of decayed matter, the germs killed, and the hole filled with a substance that resists decay and keeps out germs. This process is "filling" the tooth. It is important that the dentist find the cavity of decay when it is just starting. The dentist should examine the teeth at least every six months. If the dentist sees you often, he will not hurt you, and you will not have a toothache.

Proper cleaning of the teeth will do much to prevent decay. When little pieces of food stick between the teeth, they decay and may aid in starting the decay of the teeth. At least twice a day, and better after each meal, the teeth should be scrubbed with a brush. It is important, that the scrubbing take out

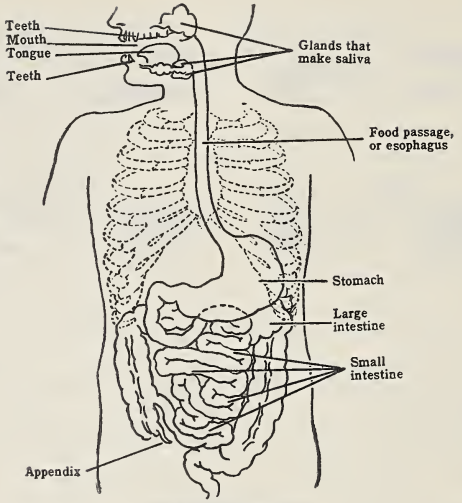


These pictures show how to use your toothbrush

any bits of food that may be there. Mere rubbing a brush across the teeth may do little good. The upper teeth should be brushed with a downward stroke and the lower teeth should be brushed with an upward stroke. Both the inner surface and the outer surface should be brushed. Make sure that the bristles of the toothbrush clean the spaces between the teeth. If the brush will not take out the food, use a thread of dental floss or a wooden toothpick. Tooth paste or powder is a great help in making the teeth clean.

Digesting the food. Digestion begins in the mouth. In the liquid that collects in the mouth, the saliva, there is a chemical substance, called an *enzyme*, which changes the starch of the food into a simple sugar. When the foods are sufficiently chewed, they are thoroughly wet and partly liquid. They are then swallowed and reach the stomach.

In the walls of the stomach there are tiny glands that make gastric juice (*gastric* means "stomach"). The gastric juice is poured into the stomach. It contains enzymes that digest certain kinds of foods, the proteins. Muscles in the walls of the stomach squeeze the stomach much as you would squeeze an inner tube full of water by putting your hands around



The digestive tract

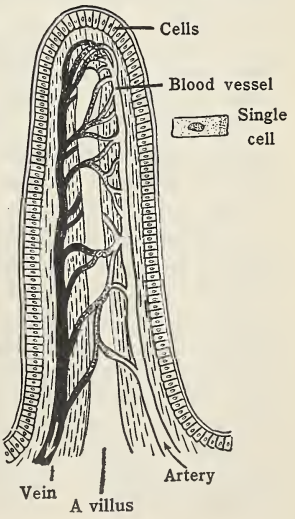
it and squeezing the contents along. This squeezing thoroughly mixes the food with the gastric juice. The better the teeth have done their work, the easier it is for the stomach to do its work. If the food has been swallowed in big chunks, the stomach must work long and hard to get the food digested into liquid.

When the stomach has done its work, the food is passed along to the intestine. Here again muscles in the walls keep the food moving forward and churn it around. More enzymes are poured in from glands. The pancreas, the liver, and minute glands in the walls of the intestine pour in liquids. The intestine is a long tube—twenty-six feet long in a man—folded inside the abdomen. Its great length gives time for digestion to be completed as the food is pushed slowly along. Eventually all the food that is digestible is digested.

Taking digested food from the intestine. When digested the liquid food is ready to be absorbed, or taken up, by the walls of the intestine to pass along to the blood. There is plenty of wall surface for this absorption. Not only is the intestine so long that it is folded many times, but the walls are wrinkled in tiny folds. In addition, thousands of tiny little projections like minute fingers jut in from the walls. [These little projections are called *villi*.] Through all these surfaces the liquid food is absorbed.

Most of the liquid food, when absorbed from the intestine, is passed immediately along to the blood. The digested fats are taken by tiny tubes [called *lacteals*], and are finally passed into the blood vessels to mix with the blood.

Getting rid of waste foodstuff. Parts of the food that cannot be digested are forced along inside the intestines to be passed out of the body. If these portions are not passed out each day, they may decay in the intestines. Decay sometimes produces poisons that are absorbed by the walls of the intestines and carried through the body. We then feel lazy and half sick or we suffer with headaches. Disease germs can more easily get a foothold in the body. It is necessary that the undigested parts of the food be passed out each day. Exercise, plenty of water, plenty of fruits and vegetables usually will bring about passage without the use of medicines.



Things to Do in Learning How Food Is Prepared to Go around the Body

I. Read the chapter.

II. Study by observation and experiment digestion in the mouth.

1. Examine your teeth with the tip of your tongue and by looking in a mirror. How many shapes of teeth do you find in your mouth and how many of each shape? Draw a little map of your teeth. Label the chisel-shaped teeth in front the *incisors;* the pointed teeth on each side of them the *canines;* the broader teeth that come next, bearing two rounded points, the *bicuspids;* the flat-topped back teeth in your cheek the *molars.* What do your incisors do to the food? your molars and bicuspids?

2. After dinner examine the teeth with a mirror and a wooden toothpick to find where remnants of the food remain.

3. Practice with a dry toothbrush the correct way to clean the teeth. Brush the upper teeth with a downward stroke and the lower with an upward stroke, both inside and outside. See if your toothbrush actually reaches the bits of food which you located. After you have brushed your teeth, test the cleaning by running dental floss or a wooden toothpick between them.

4. EXPERIMENT No. 53. How does digestion in the mouth change crackers? Take a piece of *unsweetened* cracker into your mouth. Carefully note the first taste. Then chew it, noting any change of taste. Write a report.

5. EXPERIMENT No. 54. What chemical change in a cracker is produced by saliva during digestion in the mouth? Use unsweetened cracker. Put a drop of iodine on the cracker. A blue or black color indicates starch. Break up some cracker in a test tube. Add Fehling's solution, which you can get at a drug store. Boil. If the color changes to brown or red it shows that grape sugar (glucose) is present. This part of the experiment is the control.

Break up a second cracker in another test tube. Add saliva or diastase. Allow to stand in a warm place for half an hour or more. Then add Fehling's solution and boil.

Do you find any change in the cracker with digestion? What new substance is formed? Why do we have a control experiment? Write your report in the usual form.

III. Test yourself with these questions:

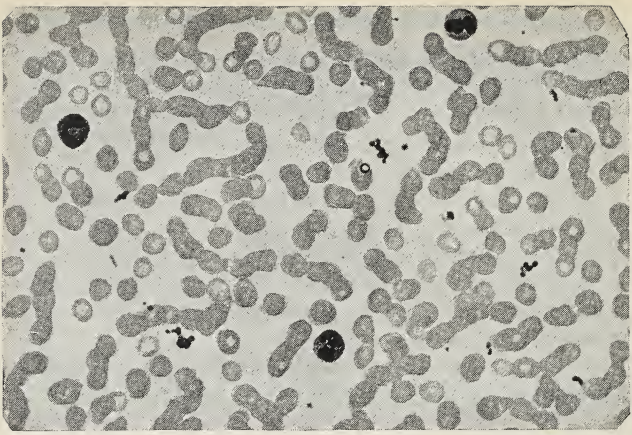
1. Why must food be digested?
2. What is the work of the teeth? What must do the work of the teeth, if they fail to do it?
3. Why should the first teeth be cared for?
4. What protects the tender inner part of the tooth?
5. What two important measures should you take to preserve your teeth?
6. What substances in the body bring about the digestion of food?
7. What happens to starch in digestion? Where does the action begin? What does this tell about the first treatment of the food which you have begun to eat?
8. How does the stomach digest food? the intestine?
9. What advantage is it to have twenty-six feet of intestine folded up inside your body?
10. Where does the digested food go when it is absorbed from the intestine?

IV. Think out these questions or investigate.

1. Why do plain crackers taste sweet when you have chewed them awhile?
2. Does milk need to be digested?
3. What may cause "indigestion," and what may be done to avoid it?
4. After a large dinner is it beneficial to "run around the block"? What is probably the best thing to do?
5. Is drinking ice water with meals a good or bad practice? Why?
6. Do you, when in a hurry, wash down food with a swallow of liquid? Is this a good or bad practice? Why?

V. Vocabulary. Remember that your own list tells you what you did not know.

alignment	enamel	molars	enzyme
permanent	incisors	pulp	gastric
crown	canine	saliva	control experiment



Sally Pepper, Phila.

CHAPTER TWENTY-FIVE

DELIVERY AND REMOVAL SYSTEMS

What is blood? Blood is mostly water. That is the reason it flows freely. In the water are several other things. There are living cells carried along in the blood stream. *White blood cells*, like microscopic animals, can leave the blood by crawling through the walls of the tiny blood vessels. When harmful bacteria get into the body, the white blood cells hurry around to the place where the bacteria are living. Leaving the blood stream they "crawl" among the cells hunting for the bacteria. They "eat" the bacteria by wrapping themselves around them, engulfing them.

Sometimes when you cut yourself and do not clean the cut and wash it with an antiseptic (substance to stop disease germs) to kill the bacteria, they may grow in your flesh. White blood cells gather in great numbers, so many that they may burst through the skin as a whitish liquid, pus or "matter." The liquid must be allowed to drain away. A doctor should see such an infected cut.

Another kind of blood cells are called *red corpuscles.* [*Corpuscle* means "little body."] The red corpuscles carry the oxygen to the cells of the body. They are red because they contain an iron compound which becomes red when it unites with the oxygen. [This iron compound is called *haemoglobin.*] When there are too few red corpuscles or when there is too little of the iron compound in the blood, the person's cells cannot get enough oxygen. The person is pale and half sick and may easily fall a victim to disease germs. [Such a person is said to be *anemic.*] The doctor must correct this condition by supplying more iron or inducing the body to form more red corpuscles.

On the facing page is a picture of human blood magnified about 500 times. The red corpuscles are in strings on the microscope slide, but not normally.

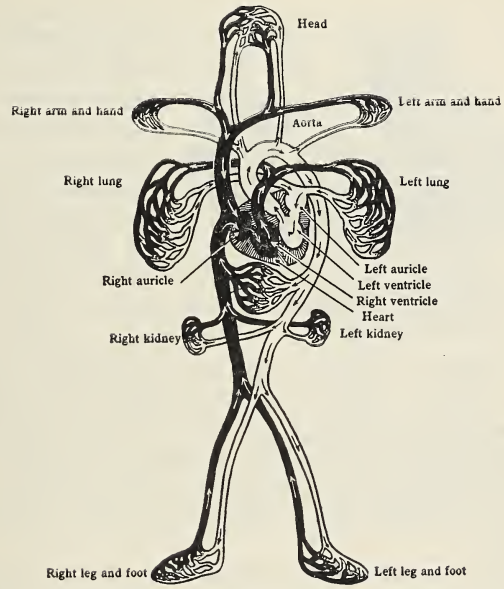
The liquid part of the blood is the *plasma.* In it, in addition to the red and the white cells, are dissolved substances that are being carried around the body. There are food substances that the blood has taken from the walls of the intestine. There are also waste substances that the blood carries from the cells to the organs that cast them out of the body.

The heart and blood vessels. The powerhouse of the system is the heart. It is a hollow muscle divided into four chambers, the upper called *auricles* and the lower *ventricles.* Blood from the lungs enters the left auricle, blood from the cells of the body enters the right auricle. From the right ventricle the artery goes to the lungs. From the left ventricle blood goes to all other parts of the body. The *arteries* (blood vessels which carry blood away from the heart) branch as they go away from the heart, the branching continuing until tiny blood vessels, called *capillaries,* are formed. The work of the blood takes place in the capillaries. Through the walls of the capillaries

pass all material to the cells and all material to be taken away from the cells. Through the walls of the capillaries in the intestines passes the food. Capillaries unite to form *veins* (blood vessels which carry blood to the heart) and veins unite again to form larger veins until the greatest of the veins empty their contents of blood into the auricles of the heart.

The heart is a sturdy organ that must keep beating throughout life. In an adult about seventy-two times each minute the muscle contracts and the heart beats. That is heavy and fatiguing work. If the heart is injured by disease or poisons, it may be permanently damaged. Therefore, the doctor tells you to remain in bed after an attack of the grippe when you think that you are perfectly well. The poisons from the bacteria in your body may injure the organs. If you rest, there is less danger. Tobacco heart and alcohol heart may result from the use of those poisons. The athletic coach does not allow the team either tobacco or alcohol. He is taking no chance with damaged hearts. Why should anyone?

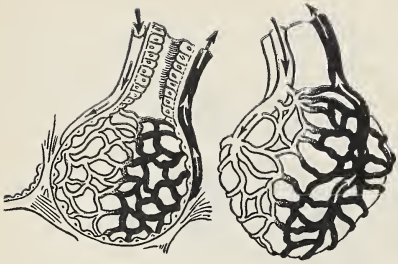
What the blood does for us. The oxidation that supplies energy to the body takes place in the cells. Oxygen is brought to them by the iron compound [haemoglobin] in the red corpuscles. Fuel foods to be oxidized are brought by plasma of the blood. Carbon in the food is oxidized to carbon dioxide. Hydrogen of the food is oxidized to water. There are other elements in the foods which are oxidized. All the oxides are wastes. They can burn no further. If they accumulated in the cells they would put out the fires of life. The blood removes them from the cells. It takes carbon dioxide to the lungs. It takes water to lungs, skin, and kidneys. Dissolved in the water are other waste substances. These dissolved wastes are carried by the blood to the skin and



This diagram illustrates the circulation of blood in man. The black vessels are the veins and the white vessels are the arteries.

especially to the kidneys to be cast out of the body. Among these wastes is the substance *urea* which is carried to the kidneys for casting out. The casting out is called *excretion.* The blood system carries. The lungs and digestive organs supply. The organs of excretion cast out.

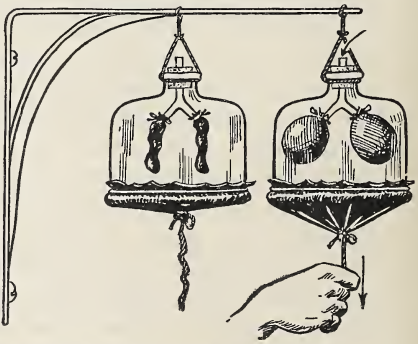
Supplying and removing gases. Only a thin membrane, thinner than the thinnest tissue paper, makes up the tissue of the lungs, and the capillary walls are as thin. As the blood goes through the capillaries of the lungs, only the thin walls of the capillaries and the thin tissue of the lungs separate the blood from the air in the lungs.



How the blood gets oxygen from the air sacs in the lungs. Black represents veins, white represents arteries.

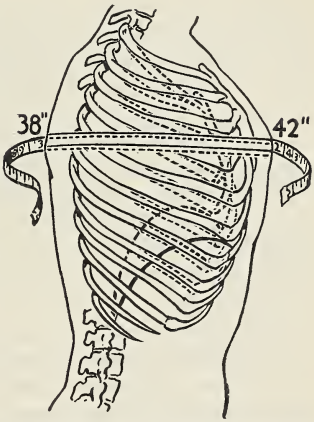
The blood coming from the cells to the lungs is heavy with carbon dioxide, and there is little carbon dioxide in the air of the lungs. The carbon dioxide pushes out from the blood into the little chambers of the lungs called *air sacs*. The air brought into the air sacs from the outside contains more oxygen than does the blood. The oxygen passes into the blood, is seized by the iron compound (haemoglobin) of the red corpuscles, and borne away to the tissues. All is done in a second, for the entire trip around the body takes the blood only fifteen seconds.

How we breathe. Air presses into the lungs by its own weight. You may recall the figures—fifteen pounds to the square inch is the pressure of the air. When you breathe, you raise the ribs and draw down the great muscle at the bottom of the chest, the *diaphragm*. This makes the chest larger. The outside air then pushes into the lungs as in the picture. About eighteen times a minute you repeat this breathing. That gives you plenty of



Apparatus showing how air enters the lungs

oxygen and gets rid of the carbon dioxide. When you run about, you use more oxygen and make more carbon dioxide. Then you breathe faster and deeper. That is one of the benefits of running about, it makes you take in more oxygen and give out more carbon dioxide. It helps to clean out the body.



The solid line drawing shows the chest, ribs, etc., when the chest is fully expanded, the drawing in dotted lines shows the chest when air is breathed out. Note the difference in reading on the tape measure.

Kidneys and skin. A second great gateway for the sending out of wastes from the body cells is the kidneys. Everything that goes out of the body that way must be dissolved in water. The kidney is made up of minute tubes. The walls of these tubes are, of course, made of cells. The kidney cells have a very remarkable habit. As the blood goes through the capillaries in the kidneys, the cells of the kidney tubes take out the wastes and pass them into the tubes. Remarkable, the cells do not take out the dissolved food and throw it out in the tubes! We do not know how the kidney cells select the dissolved waste from the dissolved food in the blood, but in health the cells choose the right thing to throw away.

The skin also has tubes through which water oozes out carrying wastes dissolved in it (page 242). They are the *sweat glands*. Ordinarily you sweat about a quart a day. Of course, the amount varies with the weather and amount of exercise, but there is always some perspiration.

Water also passes out as vapor through the lungs. You have seen the vapor condense as a white cloud in your breath on cold mornings. Even on warm days you can show the vapor in the outgoing breath by breathing against a chilled glass.

Things to Do in Learning about the Delivery and Removal Systems of Your Body

I. Read the chapter.

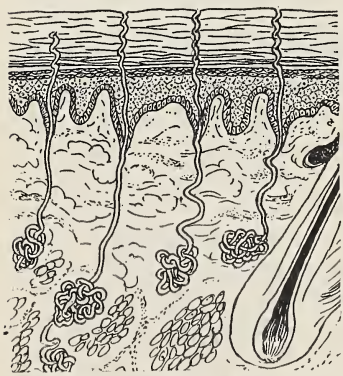
II. By observation study your circulatory and breathing systems.

1. If a microscope is available, smear a drop of blood on a slide and examine it under the microscope.

2. Count your pulse. Put the tip of your finger on the inside of the wrist on the thumb side, just at the knob of bone near the base of the thumb. You can feel the pulse easily in the artery. Count the number of beats in a minute. Do not be surprised if your heart beats more than seventy-two times a minute. Young hearts beat faster.

3. Show that you breathe out carbon dioxide. Breathe through a tube into a glass containing limewater.

4. Feel how you breathe. Put your hands at the sides of your lower ribs. Breathe in. In what directions does your chest enlarge? What makes it enlarge? Again put your hands on your stomach just below the ribs. How is the chest enlarged? The diaphragm pushes down the organs of the abdomen which swell out with each inhalation.



Sweat glands in the skin

5. If you have never noticed the moisture in your breath, cool a mirror and breathe against it.

III. Test yourself by answering these questions:

1. What does the blood do for the living body?
2. What is in the blood besides water?
3. What do the red corpuscles do for the body?
4. What do the white blood cells do?
5. What should you do with a cut in the hand?
6. Draw a diagram of the heart and label the chambers.
7. By what kind of blood vessels does the blood leave the heart? By what kind is it brought back? What is the name of the fine blood vessels which join arteries to veins?
8. Why is it said that the real work of the blood is done in the capillaries?
9. How many times a minute does the heart beat in the adult? Does yours beat at the same rate? Explain.
10. Why does the doctor want a patient to stay in bed after he has recovered from grippe or other diseases?
11. Name two common practices that are so bad for the heart that athletic coaches will not tolerate them.
12. Name materials needed by the cells and brought to them by the blood. Tell where the blood obtains each.
13. Name waste substances taken away from the cells by the blood and tell how each is cast out of the body.
14. What makes air go into the lungs when we inhale?

IV. Think out the answers to these questions:

1. Why is a child's pulse more rapid than an adult's? Why is the pulse of a bird more rapid than that of a child?
2. Why is your pulse more rapid when you run about than when you sit still?
3. Is exercise good or bad for the heart? How can you decide how much exercise?

V. Vocabulary. Ask your teacher whether you should learn words in brackets

engulf	[haemoglobin]	capillaries	urea
pus	[anemic]	arteries	sacs
infected	chambers	veins	diaphragm*
antiseptic	auricle	accumulated	inhalation
corpuscle	ventricle	excretion	

* Watch the spelling.



Keystone View Co., N. Y.

CHAPTER TWENTY-SIX

THE RIGHT FOOD

What foods do. Fuel for the bodily furnaces must be of the right kind, just as fuel for the industrial furnaces must be right. Any kind of food will not do; it must be the right kind of food. Shall it be potatoes, beef, or pie? We must know what each kind of food will supply and whether it will supply it in the right form and quantity.

In addition to supplying fuel, foods also do other things for the body cells. The cells of the body are built of the things that we eat. We must eat the right things or the right kind of body cannot be built.

Burning of fuel, building, and repairing must go on at the proper speed. Substances that we take in our food speed up or slow down the bodily processes. To regulate these processes we must understand the regulative materials of the food.

Foods, then, supply (1) fuel, (2) material for building and repair, (3) regulators of bodily processes.

Containers of breakfast cereals, brightly colored cards in trolley cars, advertisements in magazines and



Fuel foods Building foods

on billboards tell us of proteins, carbohydrates, minerals, and vitamins. They fire words at us until we are confused. They try to lead us to believe that they must be exceedingly valuable products because scientific words may be used about them. Let us try to see what the science is behind the words, then we may use our own judgment about their value.

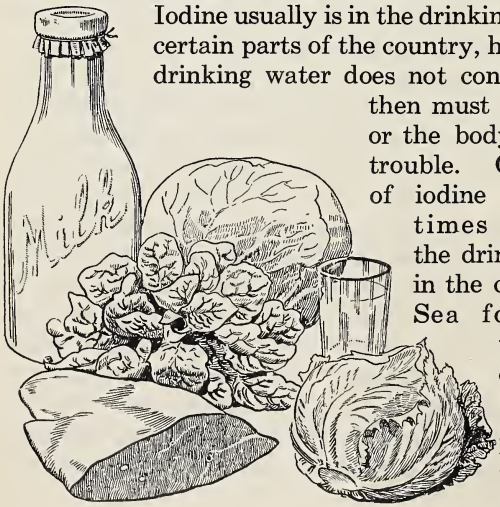
Fuel foods. The foods that serve as fuel are of three kinds. They are fats, carbohydrates, and proteins. You have an idea what fats are. Carbohydrates are sugars and starches. Potatoes, bread, peas, and beans are some of the foods that contain starches. Proteins are contained in the lean part of meat, in eggs, in fish, also to a lesser extent in bread, peas, and beans. The richest fuel food is fat. That is, an ounce of fat will give more heat than an ounce of carbohydrate or protein. Therefore in cold countries fat is eaten in large quantities. The Eskimo is famous for his taste for blubber (fat) of seals. These food substances all contain the elements carbon, hydrogen, and oxygen. Proteins in addition contain nitrogen, sulphur, and usually phosphorus. Some other elements are required in the body. Calcium, potassium, sodium, magnesium, and also iron are needed and are in the foods.

Building foods. In addition to furnishing fuel, proteins supply material to build and repair cells. Nothing can take the place of protein for building and repair. Children's bodies need more building than adults', and proportionally more protein. This protein must be of the right kind. The protein of peas and beans is good, but it is not a "complete" protein. The protein in lean meat and eggs is more nearly complete. Therefore children must have animal protein, milk, eggs, and lean meat.

Eating minerals. Most mineral substances that we need are contained in our food in sufficient quantities. We need to take thought of calcium, however, an element that is especially needed in bones and teeth as well as in other places in the body. Milk is rich in calcium. Leafy and green vegetables are fair sources.

Iron is sometimes lacking in sufficient quantities in the diet. Red meats, especially liver, and green vegetables are sources of iron compounds for the body.

Iodine usually is in the drinking water. In certain parts of the country, however, the drinking water does not contain it. It then must be supplied or the body will have trouble. Compounds of iodine are sometimes added to the drinking water in the city supply. Sea foods contain sufficient iodine to keep a person healthy.

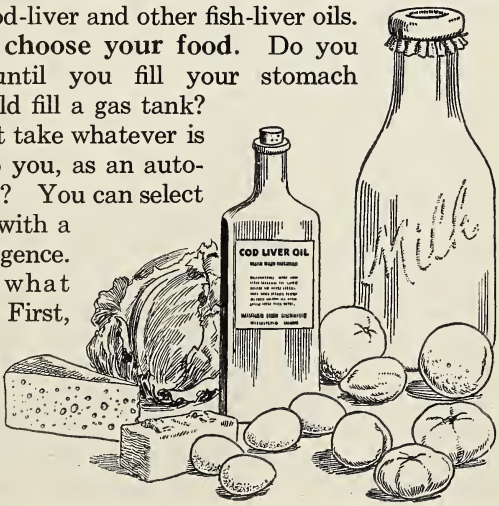


Mineral foods

Foods that regulate. Vitamins regulate the processes of the body. Proper growth and health are impossible without a sufficient supply. If there is serious deficiency (lack) of vitamins, certain "deficiency diseases" develop. Scurvy, rickets, beriberi, and pellagra are diseases due to lack of vitamins.

The vitamins are designated by letters. Vitamins A, B, C, D, E, and G are known. There may be others. With the varied American diet usually there is little trouble. For those who get a varied diet with plenty of fresh fruit and vegetables, fresh meats and eggs, milk and butter, there is little to fear. Many people, however, even in America, are suffering because they cannot get the fresh foods. Vitamin D needs to be watched especially in children, because growth is seriously interfered with if the vitamin is not present in their food or if they do not get plenty of sunlight. Apparently if we are much in the sunlight, our bodies can manufacture Vitamin D. The richest source of Vitamin D is cod-liver and other fish-liver oils.

How to choose your food. Do you just eat until you fill your stomach as you would fill a gas tank? Do you just take whatever is poured into you, as an automobile does? You can select your food, with a little intelligence. Here is what you need: First, some food for building and repair; second, some fuel



Vitamin foods

food; third, some regulating food; fourth, some minerals; and fifth, plenty of water.

The building and repair foods are the proteins. The best for the human body are found in milk, eggs, and lean meat. Fish is also very good protein and in addition brings in some other things needed by the body. Make sure that you get enough milk.

The fuel foods are chiefly fats and carbohydrates. The carbohydrates are sugars and starches found in bread and other cereals, in potatoes, and in general in foods which are made from roots and seeds. The carbohydrates usually are the biggest part of your diet. Fats are richer in fuel, but except outdoors in cold climates they are not so good for us as the carbohydrates because they are not so easily digested. For people who spend most of their lives indoors or in warm climates, milk, butter, and eggs give all the fat that is needed. These three foods are valuable for other reasons. They contain vitamins, and milk and eggs contain proteins.

The foods that regulate the bodily processes are the vitamins and minerals. Fresh fruits, fresh vegetables, salads, green leaves, such as lettuce and spinach, contain one group of vitamins. The yolk of eggs, butter, milk and cream, and liver contains another group in addition to some of the first group. Fresh meats, not dried meats and salt pork, contain other necessary vitamins. You will notice that the vitamins are in fresh things—fresh fruits, fresh vegetables, fresh meats, and milk products. In this list there is danger of shortage in only one vitamin, Vitamin D. The pleasantest way to get that is to stay in the sunshine winter and summer. When the sunshine falls on the skin, the body makes its own Vitamin D. If sunshine is not falling often on the skin, cod-liver oil or the oil from other fish livers is

Food	Calories in Usual Serving	Food	Calories in Usual Serving
Round steak	125.2	Fricasseed chicken	187.0
Cocoa	123.0	Apples, baked	98.5
Orange juice	75.5	Oranges	75.0
Graham bread	151.3	Pineapple, canned	145.2
Whole-wheat bread	142.5	Pork chops	309.0
Farina	421.2	Blanc mange,	148.8
Oatmeal	67.1	Tapioca pudding	146.3
Butter	112.7	Date and nut salad	124.1
Whole milk	121.9	Asparagus, on toast	202.8
Omelet	296.0	Carrots	49.2
Salmon, canned	114.1	Potatoes, baked	98.1

Table of calories in some common foods

the richest source of Vitamin D. There is some danger that you may get too much cod-liver oil, however; it is better to ask the doctor when you should take it.

How much to eat. You usually eat until you are satisfied, and on the whole, it is not a bad idea, if you select the kind of food as directed. Very often, however, well-fed children are very poorly nourished because some necessary food is lacking in the diet. If you choose your foods in the order mentioned in the last section you will probably get enough of everything and you will probably eat about the right quantity provided you get plenty of exercise in the sun and wind. The kinds of food that are lacking in undernourished children are usually proteins and vitamins. If you eat two eggs at one meal, and a piece of meat not larger than the palm of your hand at other meals, and a glass of milk at each meal, you will get enough protein. Make sure you get the foods which contain vitamins. Then satisfy your hunger as you wish. In addition get exercise in the sun and wind.

Food values are measured in calories. A *calorie* is a certain quantity of heat. The table shows you



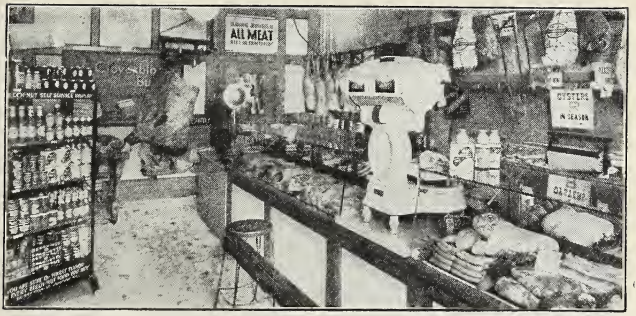
Underwood and Underwood, N. Y.

Food exposed to germ-laden dust often causes sickness

about how many calories are in some common foods. The total quantity needed each day by a twelve-year-old boy or girl is about 2400. The number of calories varies with your activity and the season.

Eat clean and unspoiled food. You do not care to eat filth and disease germs, but unless you take thought you will eat both. Perhaps you have heard it said that you will have to "eat a peck of dirt" before you die. Well, if you eat it too fast, you will die sooner. Better not eat it when you know it. Dirty hands not only have plenty of dirt and filth to put on your food, but they are sure to have plenty of disease germs as well. Disease germs are on door-knobs and books, pencils and almost everything else that you handle. Better clean them off your hands before you handle food. It may be a little trouble sometimes, but it is a lot more trouble to be nursing a sore throat or to be lying in a bed when the sun is calling you outdoors. Take the germs off your hands with plenty of soap and water before you touch your food.

Keep the food clean and away from the dust. Cakes and pretzels exposed at the curb and handled



Keystone View Co., N. Y.

This food is properly protected from germs

with filthy hands by the dealer, have collected loads of germs from the dust blown up from the gutters, germs of tuberculosis, of sore throat, of intestinal diseases, and of skin sores. There is no use eating them. Eat food that has not been exposed to flies and the winds that blow dust from the gutter.

Have you seen a piece of bread that has been forgotten until it is covered with mold—white, gray, black, red, or green. There are many molds and bacteria that blow around in the air and settle on the bread, meat, and other foods. These bacteria and molds destroy good food and make it dangerous to eat. Keep the food in the refrigerator and covered from the dust. Bacteria that are in the milk not only sour it but also make it dangerous. Wash the mouth of the milk bottle with soap and hot water before you open it. What is the use of getting a sore throat from germs



A minute's work with soap and hot water may prevent sickness

on the bottle that has been handled by dirty hands and left standing on the doorstep. Put the milk bottle in the refrigerator as soon as you have finished with it. Why let it spoil when you have paid for it, or why let it collect sore throat germs for you?

The government tries to help you get unspoiled food. The inspectors watch the meat at the slaughter houses to take out any that is diseased. The inspectors of most city or State governments examine the dairy farms, the milk plants where the milk is bottled and stores where food is handled. In most cities, restaurants and the people employed in the restaurant are inspected to see that the food handlers are free of disease and the kitchens and refrigerators are kept in condition that will not endanger your health.

The Pure Food and Drugs Act of Congress helps to keep you from being poisoned by spoiled food or food that has been "doctored" up with dangerous chemical substances to keep it from spoiling. Look on the cans and boxes for a description of the contents. Goods that are found to be misbranded or spoiled are seized by the government agents. You have probably learned in your history studies that Congress controls only those goods that are sent from one State to another, interstate commerce. The Pure Food and Drugs Act does not give you entire protection, but it is good as far as it goes.

Things to Do in Learning How to Select the Right Kind of Food

I. Read the chapter.

II. Study by observing.

1. Make posters showing the different classes of foods. These posters may be illustrated by pictures clipped from advertisements in magazines and elsewhere, as well as by labels from cans.



Ewing Galloway, N. Y.

Government food inspectors help protect our health

2. Keep note of everything that you eat for three days and see if you get the necessary food substances. Note particularly your intake of protein and vitamins.

3. Watch carefully in stores, restaurants, lunch counters, including your school lunch counter, to see if there is any chance of getting dirty or spoiled food.

4. Are your hands clean when you eat? If you eat lunch at school, are there proper facilities for cleaning your hands first? Make recommendations for change of conditions if they are unsatisfactory.

5. Read the labels on cans of food to see if you are protected from spoiled and adulterated foods.

6. Examine carefully the tops of milk bottles as they are brought into your home or served to you at school. Are they fit to pour milk from? What should be done?

III. Test yourself by answering these questions:

1. Tell three things that food supplies to the body.

2. Tell three kinds of food substances that supply fuel to the body. Name some foods that supply each kind of food substance.

3. Name the food substances that supply the building material for the body and some foods which contain this kind of substance.

4. Name the three minerals that we should keep in mind in selecting foods and tell foods which contain each.

5. In general what kinds of foods contain the vitamins. Which of the vitamins may be low in the American diet and what should be done about it?

6. Plan three meals that would give you all the necessary food substances in the course of the day. It is not necessary that they should all be in the same meal.

7. What precautions can you take to see that you get clean food free of disease germs?

8. Tell how several different kinds of foods should be kept to prevent spoiling. What precautions should you take before and after you open the milk bottle?

9. How does the United States Government try to protect you from spoiled food? What can you do to make sure that you are getting government-inspected food at the butcher's?

IV. Think out and investigate the answers to these questions:

1. Plan a food supply for a week's camping trip.

2. If the United States Government cannot protect your meat killed and sold within your own State, what should be done about it? What has been done about it in your State?

3. What food substances are contained in candy?

4. What does your city do to protect you when you eat in a restaurant?

V. Vocabulary. Suggestions. Are you sure you know what cereals are? See the dictionary just to make sure. You may know.

cereal	carbohydrate	vitamin
protein	deficiency	calorie



H. Armstrong Roberts, Phila.

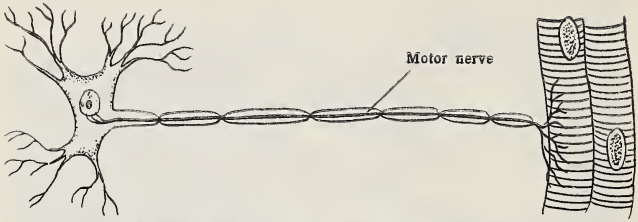
CHAPTER TWENTY-SEVEN

GOVERNING YOUR BODY

The governors. A ball comes sailing through the air toward your head. A picture of the coming ball flashes in your eye. The information almost instantly reaches the brain. In another moment a whole series of muscles have contracted in the proper order, you duck or side-step or both, and the ball sails harmlessly by, or you put up a hand and catch it.

To make all the muscles move effectively, not twitch and pull against one another, there must be a governing center. There must be means of communication from the center to the hundreds of different parts. Information must go from the outlying parts to the center, and orders must go from the center to the outlying muscles, and other parts.

Picking up information from the outside, sending it to the governing center, and sending back orders to the muscles, are the work of special cells. They are the cells of the nervous system. Nerve cells (or neurons) are peculiar in shape (see page 256). Long branches extend out from them. The cells lie



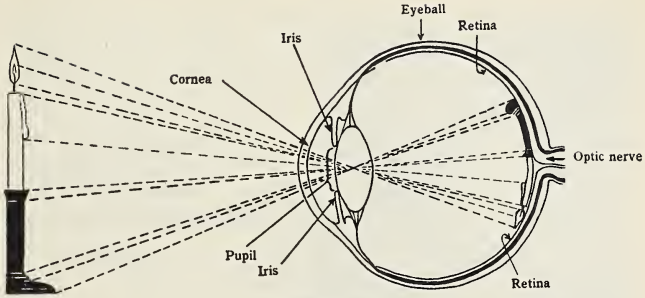
A nerve cell and the muscle fiber it controls

in groups or nerve centers [called *ganglia*], and their united branches stretch away as nerves.

Getting outside information. The nerve cells that pick up information from outside the body are arranged in sense organs, eyes, ears, organs of smell, taste, and touching. The nerve cells that are affected by light lie at the back of the eye, forming the *retina*. On the retina the image of the object outside is focused by the lens, as is shown in the picture opposite. Then the optic nerve carries the information to the brain.

Very often there are defects in the eye that need correction before it can see efficiently. It is important that every person have his eyes examined by a doctor who specializes in treatment of the eyes. Glasses may be ground to correct most eye defects. To attempt to read without glasses strains the eyes. Eyes are too valuable to be strained by abuse. It is important that there be sufficient light, but no glare on the book. Eyes are quickly damaged by improper lighting.

The nerve cells of hearing are in the inner ear. Sound is due to vibration, or shaking, usually in the air. The vibration may be in water when you put your ear under water. It may be in metal when you put your ear against a trolley pole. The vibrations are carried down the canal of the ear and eventually reach the ends of branches of the nerve cells of hearing.



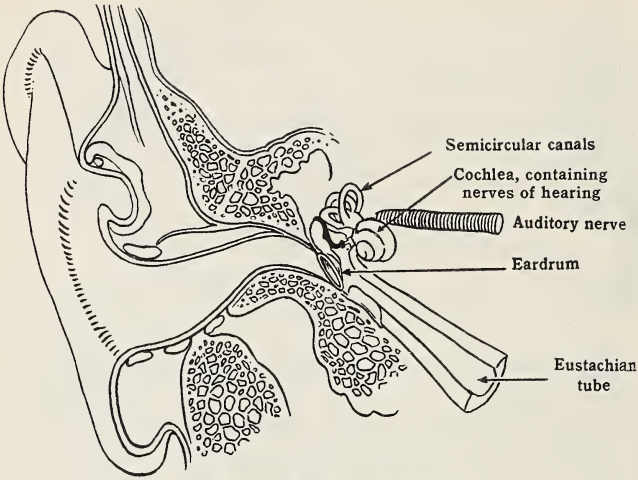
How we see

These branches are like minute hairs projecting out into a liquid in the inner ear. The vibrations of this liquid stimulate the nerve cells and the stimulation is carried to the brain by the nerve of hearing. The inner ear also contains the semicircular canals which are organs of balance. They let you know when you are wrong end up or tilting on your side.

Loss of hearing may be due to injuries to part of the ear or to disease which damages the nerve. A blow on the ear may force a blast of air down the ear and break the ear drum. Sometimes the protective wax in the ear collects and hardens in the canal, causing temporary deafness. If the wax cannot be removed with a soft cloth, a doctor should examine the ear.

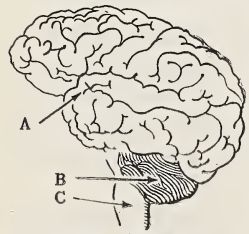
The nerves of smelling end in the membrane that covers folds of bone in the nose. The nerves of taste end in several parts of the tongue. Nerves that give us the sensation of touch end in various parts of the skin. By all of these senses combined we get an idea of the world around us.

Knowing and doing things. Large groups of nerve cells and their branches make up the brain. Extending down from the brain, protected inside the



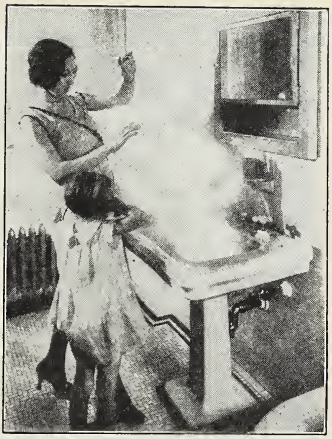
The parts of the human ear

backbone, is the spinal cord made of nerve cells and branches. The cells of the brain lie on the outside of the brain making up the gray matter. The interior of the brain is a mass of branches which connect different parts of the brain with one another and with other parts of the body. The surface of the human brain is folded in many ridges, or *convolutions*. The folding gives space for more gray matter. The gray matter of the convolutions is the thinking part, as well as the feeling part of our body. With it we enjoy the world or grouch over it; we see, hear, smell, and taste. It is the seat of all our emotions and sensations. The cells in the convolutions connected by the branches carry on our mental life.



A man's brain
A, cerebrum; B, cerebellum; C. medulla oblongata.

Below and behind the larger brain (called the *cerebrum*) is the lesser brain (called the *cerebellum* or "little brain"). The cerebellum keeps us walking straight, standing straight, enables us to sit down, or walk around without getting our muscles all mixed up in the attempt. It makes the various muscles act in the proper order. We say it *co-ordinates*.



Keystone View Co., N. Y.

Reflex action saves us many injuries

At the top of the spinal cord is an enlargement called the *medulla*. It keeps the heart beating, the breathing going on, the muscles of the stomach and intestine contracting in proper order. The medulla attends to involuntary actions so that they go on without our bothering about them. That is a blessing. We could get little studying done if we had to keep our minds on these bodily operations—or little playing.

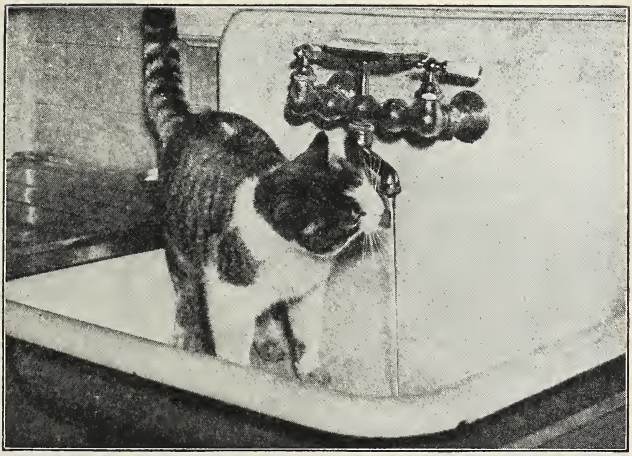
Doing things without knowing it. Did you ever tickle the foot of your baby brother when he was asleep? The foot perhaps withdrew without his waking. The cells of his spinal cord took care of that. A message went into the cells of the cord. And an order went out from the cord center to the muscles, and the leg moved. Your brother did not have to waken to attend to the matter. We have many actions of that kind. The pupil of the eye contracts when we go into a bright light; one eye winks when something sails near it. The hand jumps away from a hot pipe. If we had to think about these actions first, we might

get hurt. Nature takes care of the action first and may tell us about it afterwards. Such actions that are accomplished without our taking thought are called *reflex actions*. They save us a lot of bother and get quick action when it is needed to protect us.

You can train your nervous system to take over some more work to relieve you of bother and give you time to think. When you were learning to write, to skate, or ride a bicycle, you had to keep your mind on the business. Now you can think of something else while you ride. You can think what you will write about instead of how the letters are formed. Walking, writing, riding, even washing, becomes a habit. Such habits, that save time and thought, can easily be formed. All you need to do is to do the thing right at the right time. Soon you will be doing it right almost without knowing it, even washing your teeth after meals. The important thing in forming a correct habit is to do the thing exactly right each time. It is just as easy to form the habit correctly as incorrectly. Just do it exactly right until the action goes on without your thinking about it. Try it.

How your brain is better than a dog's. A bird sees and hears better than you do, a dog has a better sense of smell than you have, an earthworm's sense of feeling is keener than yours, so keen that it can feel the vibrations of the ground as you walk. A dog or a bee can remember, and so can an elephant. Your dog distinguishes persons and places, perhaps as well as you can.

But you have a feeling that there is one thing that you do better than any of the lower animals. You think better. In your course in science you have been learning habits of thinking. You first thought up or had presented to you a definite question. You observed certain facts, occurrences. You compared



Philip D. Gendreau, N. Y.

Does an animal think?

what you saw, heard, smelled, tasted, or felt. You decided what the facts were. You compared the facts. You drew a conclusion as to cause and effect. Then you tested out your conclusion. This is reasoning, thinking. It enables you to learn whether an eclipse announces a catastrophe, whether a bluebird flying into the house means a death in the family. By thinking you can distinguish between superstitions and scientific demonstration.

Things to Do in Learning How Your Body Is Governed

I. Read the chapter.

II. Study body control by observation and experiment.

1. Make a rough sketch of the eye and label its parts.

2. Try out an arrangement of book and light where you study at night so that their is plenty of light but no glare on the book.

3. EXPERIMENT No. 55. How does sound reach you? Lay your ear against the far end of the table. Have one

tap the table *gently* with the knuckles. What do you notice? Lay some shot or beads on the table. Lay a small board near by to protect the table. Hammer the board with a hammer. What happens to the shot? Set a glass of water on the table and hammer. What happens to the surface of the water? What did the shot and water tell you happened when you heard the blows of the hammer? What did your ear tell you? What carried the sound to your ear when your ear was against the table? When your ear was not against the table? What is sound?

4. Turn to page 258 and tell how vibrations of the air can affect your brain.

5. Experiment No. 56. Make a drawing of the back of your hand. Take a needle and gently touch the sharp point at various spots. Determine the spots where you feel a pain and spots where there is little sensation. Mark them on the drawing of your hand, a tiny cross for the pain spots and a tiny circle for spots with none. Write up a report of the experiment in the usual form. Think out the question and procedure. Under "conclusion" write down the answer to the question: Why do you feel pain in some spots and not in others? Under "results," paste in your notebook, the map of your hand, or you may draw it in place.

6. Write down the names of the different parts of the brain and tell what each part does for you.

7. Experiment No. 57. Sit down in a chair. Cross your legs. Have someone give you a sharp rap with the edge of the hand, just below the kneecap. Nothing will happen unless the blow is given in the right spot. Then what happens? What is the name for this kind of action?

8. Select an action that you wish to make a habit. Do it exactly right at frequent intervals. This may take several weeks to complete, but if the habit is worth acquiring, keep at it. You might select washing your teeth immediately after meals, or washing hands immediately before eating.

9. In what part of the main brain does the thinking power lie? Describe the appearance of this part in the picture on page 258.

III. Test yourself with these questions:

1. What kind of cells govern your body? What is peculiar about their shape? What are nerves? What is the name for little centers formed by groups of nerve cells?

2. What organs gather information from outside your body?

3. Trace the path of light and its disturbance until it reaches the brain.

4. Similarly trace sound and its disturbance.

5. From your experiment of pricking the back of your hand with a needle, what did you conclude about the organs by which you feel things?

6. From your experiment with book and light, what did you conclude about the arrangement of book and light? Make a sketch or plan to show the proper arrangement.

7. Sometimes your usually good hearing may become impaired. What would you suspect was the trouble and what would you first do?

8. Where are the thinking cells of the brain? What part of the brain makes you walk straight without thinking about it? What, in general, would you say is the work of this part of the brain?

9. What part of the brain keeps you breathing and your heart beating? What, in general, is the work of this part of the brain?

10. What name have we for such actions as the contracting of the pupil of the eye when you go into a bright light? Mention other acts of the same kind.

11. What are the advantages of habits? How can you form a good habit?

IV. Think out these answers:

1. Can dogs be trained to new habits? Can dogs be taught to think? Go carefully in answering these questions. Did you ever see a dog trained to new habits? Did you ever see a dog do an act that required thinking?

2. A rabbit's brains do not have convolutions on the surface. What mental action can the rabbit not do as well as man or not do at all? What can a rabbit do just as well as you can?

3. What is the difference between your mental action in answering questions under Group III and questions in Group IV?

V. Vocabulary. Some of the words suggested are common words of everyday use and some are words used in a scientific sense. We need both to tell our thoughts and learn the thoughts of others. Be on the lookout for all new words. These are merely suggestions. Trust to your own list.

involuntary	convolutions	retina	catastrophe
reflex	communications	vibrations	



H. Armstrong Roberts, Phila.

CHAPTER TWENTY-EIGHT

KEEPING FIT

Play in the sun and wind. Most of your body is muscle, and muscle gets flabby if it is not worked. Blood must go through the body, and the circulation gets sluggish if you do not make the heart work a bit. Your brain gets foggy and your body gets lazy if you do not stir them up with fresh oxygen and brisk circulation. Breathe deeply to get rid of carbon dioxide and get in more oxygen, but the way to make your body want the oxygen is to play in the sun and wind. Standing up and breathing deeply by force may have a value, but playing briskly takes care of breathing and circulation. It stimulates hunger, digestion, and excretion also. Play in the sun and wind, baseball, tennis, skating, swimming, hiking, anything that you enjoy outdoors. Outdoor work, too, is fun and good medicine, the garden, the lawn, the woodpile, shoveling snow, even washing the windows and steps, and washing the car.

Perspire. Brisk work brings perspiration. That is nature's way of keeping you from getting too hot.



One does not need heavy clothing when one is active

You know that if you fan your perspiring face, it cools. Evaporation of the moisture cools the skin. The increased perspiration balances increased oxidation within your body when you play hard.

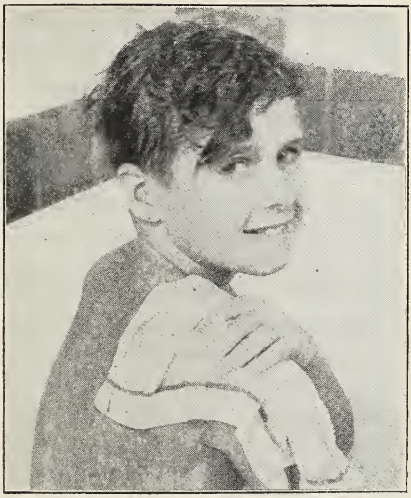
However, do not cool off too quickly. Throw a coat over your perspiring body when you sit down, especially if it is a cool day. Athletes pull on sweaters or wrap blankets around them. In wintertime throw off some of your heavy wraps when you exercise. Do not get your clothing soaked with perspiration. Wet clothing chills the body, and is dangerous in cold weather. Take off your heavy sweater before you get in heavy perspiration and pull it on again before you get cool.

Then bathe. The sweat glands send out many substances dissolved in the perspiration. When the water evaporates, these dissolved substances remain behind. If they collect on the skin, they cause irritation and bad odor. Wash them off frequently. The athlete takes a shower after exercise. Do the same. If you do not have a shower, a basin of water and a wash rag will do just as well. A bath a day is an easy habit to form. And change the underwear frequently. It does not take more than a few minutes to wash a suit of light underwear, and clean underwear feels and smells much better. Cleanliness is cheap, healthful, and pleasant to yourself and your friends.

Rest. Long rest is just as important as exercise. If you drive yourself too hard, you will wear out

and get sick easily. A farmer does not drive his horse until it is dead tired. He rests it from time to time during the work periods, and he gives it a long night in the stable and a day off on Sunday. Ceaseless hard work would ruin the horse. Ceaseless work will ruin the human body. Play is hard work. If the body is overworked without sufficient rest, it wears out. Fatigue is dangerous. Disease germs grow more easily in the tired body than in the body that glows with health and vigor. Stop work and play now and then to rest, and rest until you are rested. But do not get cold while you rest; put on your coat or sweater.

Sleep is the most important rest. It is the most nearly complete rest. Eight good hours of sleep is needed by an adult each night and eleven by a twelve-year-old boy or girl. The best hours to go to sleep are before midnight. You cannot make up lost sleep in the morning. You get in the habit of waking at a certain hour, and then lie drowsily in bed. Go to bed early if you want to enjoy life.



H. Armstrong Roberts, Phila.

Daily bathing is important to health and comfort

How not to get sick. To avoid getting sick, use your head. You know the right kind of food. You know that



Keystone View Co., N. Y.

Plenty of sleep and fresh air are necessary for everyone

you must have exercise, rest, and sleep in the right kinds and quantity. Do something about it. Keep yourself feeling as if you could whip your weight in wildcats.

On damp, cold days, keep dry. Do not go around in wet clothes. If your clothes get wet, go home and put on dry clothes. Umbrellas, raincoats, and rubber shoes will save you from colds, grippe, and sore throats. Use them. Do not stand on a cold, windy corner on a winter night waiting for a car. Walk and keep warm until the car comes. Do not get dead tired and then stay out in the cold. Get warm and rest. The grippe germs get you more easily when you are tired.

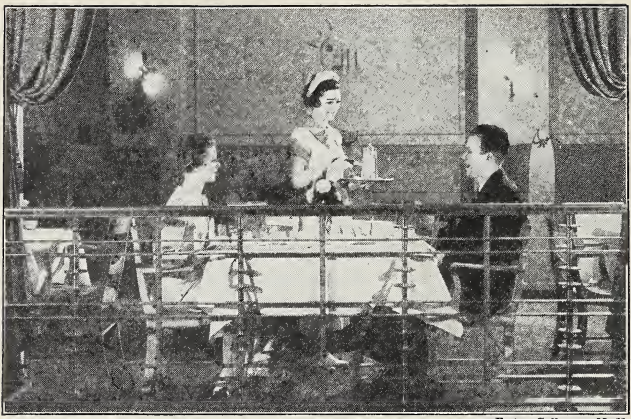
Open the windows before you go to bed, and, if it is cold, roll the blankets tightly around you. Do not get cold at night. In the daytime as well as at night,

see that the air you breathe is fit to breathe. It must be fresh, moist, but not too wet; moving a little, but not drafty. An overheated, stuffy room either too humid or too dry will help to give you a cold.

No monkey backs. Do not sit with your back curved like the back of a pretzel. Sit straight. Stand straight, not like a letter S. Roll back your shoulders and "blow out your chest." Give your lungs and heart a chance. Do not crowd them so that they cannot work easily. Walk with your head up, not sagging down like a cow's. Hold your head and eyes up as if you dared to look any man in the eye.

You will need to take care of the muscles to make them hold you up like a man instead of letting you bend over like a monkey. You now know the kind of food they need; give it to them. You will need to train them and work them. They will not get strong and lively with loafing. Make them act alive and obey you. Then when they have earned a rest, give them a good long night's sleep. Put them to bed early as the athletic coach does his players. That is the way to get teamwork out of them.

Fight disease germs. First, keep germs out of the body, if possible. Second, keep the body in condition to destroy germs if they get in. To keep the germs out, keep away from them and keep them away from you. Wash them off your hands before you handle your bread and cake and dishes. See that the dishes are thoroughly washed and then kept clean and away from dust. Many restaurants are careless about cleanliness of dishes and employees. Look at the hands and fingernails of the waitress to see if they are clean. Watch the dishes, knives and forks. Find out about the restaurants in which you eat. In well-governed cities, the public health officers take care of the restaurant as far as they can. They cannot



Ewing Galloway, N. Y.

Eat where everything is clean and neat

do everything. You, too, must watch the places where you buy food. Do not eat and drink disease germs.

Try to avoid breathing in germs. This is more difficult. When there is an epidemic of colds and sore throats in your town and people are coughing everywhere, do not go into theaters, stores, and other places where there are crowds if you can avoid it. Do your part if you have a cough. Cover your mouth with a handkerchief before you cough. Do not spray your family and your friends with the germs of your throat and nose.

Germs of disease also collect upon the skin, and skin disease is often hard to cure. Cleanliness and care can keep one free of such disease. Frequent use of soap and water is the first precaution. Small insects, such as lice of several kinds, get in the clothing and then about the roots of the hair. Once established, these insects are troublesome and require careful treatment to destroy, but frequent use of soap and water will prevent their becoming established.



Don't spread disease when you sneeze

Do not use towels or drinking cups that may be used by others. Paper cups, paper towels, and sanitary drinking fountains are much safer. Even within your own house each should have his own toilet articles and cup in the bathroom. If one member of the family has collected some germs of cold and sore throat, there is no reason why everyone in the house should get them.

Do not use hats and other clothing of another. Germs and insects are easily carried from one person to another by such means. Keep pencils and fingers out of your mouth and away from your face.

Your parents, your school, and your city will see to it that you are vaccinated against smallpox and given preventive treatment, if you need it, to keep you from getting diphtheria. In localities where these vaccinations and treatments are not enforced, the sickness and death rates from these diseases are much higher.

No patent medicines. Look out for quack doctors and patent medicines. Most patent medicines are water, alcohol to make you feel a little warm inside for awhile, a little dye to make you think you are getting something, a little sugar and flavoring to make you want more, or a little bitterness to fool you. Let the doctor prescribe the medicine. He has spent a great many years trying to learn what medicine will do to make you well. He probably knows a little more about medicines than the storekeeper. The



Don't fool yourself

reliable drug store is always glad to have you bring a prescription from the doctor rather than come in and ask for something to cure you.

Things to Do in Learning How to Keep Fit

I. Read the chapter.

II. Study keeping fit by planning, doing, and observing.

1. Keep a time sheet of the time you spend: with your muscles working, in eating, in resting, in studying, in sleeping. How does your time schedule compare with the advice of the chapter?

2. EXPERIMENT No. 58. Try the experiment of fanning your perspiring face (or wet your face with water) and letting it cool without fanning. Which makes it cooler? Which is the safest way to cool off?

3. EXPERIMENT No. 59. If you have not developed the bath-a-day habit, try it and see how little trouble it is and how much better you feel.

4. Make a determined effort to get the right number of hours of sleep and see how well you feel.

5. Make a list of the habits of health you need to develop. Keep a score card. Each evening mark with a

plus those things that you have done right and with a minus those which you have done wrong.

III. Answer the following questions as a test:

1. In how many ways does bodily exercise in work or play help you?

2. What two uses does perspiration serve? What precaution should be taken when you are perspiring?

3. What good is a bath? If you have no shower available, how can you get just as good and as quick a bath?

4. How much sleep should you get every twenty-four hours?

5. Why are wet clothes bad, especially in cool weather? What should you do about it?

6. How should your bedroom be arranged at night?

7. Why are rounded shoulders and back bad for you? How can you straighten them out? What is the healthy position of head, chin, shoulders, and back when sitting, standing, and walking?

8. What can you yourself do to keep disease germs out of the food you eat? Do you do it?

9. What can you do yourself to avoid getting colds?

10. Do you use personal articles, such as brushes and cups, belonging to another? Why is it a bad practice even in your own family?

11. What is wrong with patent medicines in general?

IV. Think out the answers to these questions:

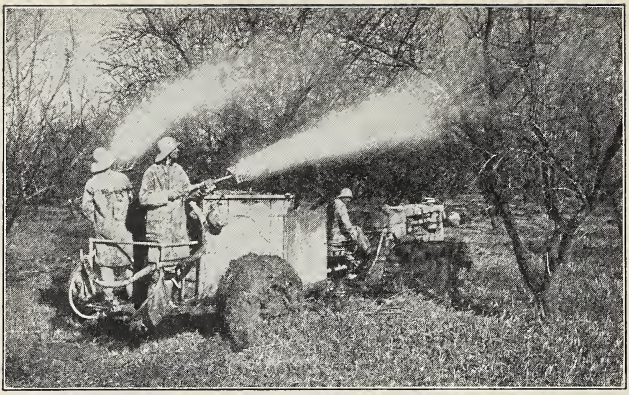
1. What kind of outdoor sport can you get in your neighborhood? Which outdoor sports that you can get with some effort have you not tried? Why do you not try it?

2. Why is it unwise to play hard just after a heavy meal? Why is it hard to study then?

3. Why are wet feet dangerous in cold weather?

4. What should you do if you have a headache? The correct answer is not, "Take an aspirin tablet or other 'headache medicine'."

V. Vocabulary. Did you find any new words for your list?



Caterpillar Tractor Co.

CHAPTER TWENTY-NINE

POISONING YOUR BODY

Poison on your food. You would not deliberately put poison on your fruit, but the grower generally does. He does not do it to kill you but to kill insects. Suppose that poison is not taken off the food before you eat it. There have been many cases of deaths from fruits sprayed with poisons, and hospitals, especially childrens' hospitals, constantly report sickness due to poisons.

The poison generally used in spraying fruit to protect it from insects is lead arsenate, a compound of two poisons, lead and arsenic. People have been poisoned by water flowing through lead pipes. One of the great difficulties in fighting lead poisoning is that when a little lead gets into your body, it stays there. An extremely small amount of lead may not poison you, but if it stays in your body and you keep adding small amounts, you will finally get enough to poison you. Even handling white lead in paint causes painters' colic or wrist-drop in which the arms are partially paralyzed. If it poisons you when you

merely handle it and get it on your hands, what will it do when you eat and drink it? Many people are eating and drinking lead poison. They get it a little at a time, but according to the medical reports, they are poisoned in the end.

Arsenic is a poison that has been used to kill rats, wolves, and prairie dogs and for murder. It is quick and deadly. The Federal Pure Food and Drug Act forbids fruit growers to sell you their fruit to eat if it has on its skin more than one one-hundredth of one grain of arsenic in a pound of fruit. That amount of arsenic poison would not kill you, but suppose you eat fruit, peas, carrots, potatoes, cauliflower, cabbage, lettuce, and other vegetables, each of which contains some arsenic. You eat them day after day. You might get a very considerable amount of poison. It is little wonder that hospitals report many poisoned children.

If you do not want to eat poison, pare your fruit. Get every bit of skin off. Watch those little ends of the apples where the stem is attached and the opposite end where the petals of the flower were attached. The poison spray collects at those spots. Cut them out and throw them away. Applesauce made without paring the apples is delicious, but it may be poisonous. Pare the carrots and throw away all the outer leaves of the cabbage and lettuce. A little poison may get inside the cabbage leaves, but a lot gets on the outside. Dried fruit is especially



Pare fruit to avoid the chance of eating poison



Some canned goods contain harmful preservatives and dyes

dangerous. You cannot pare it. You must wash it very thoroughly.

Government regulations require that all apples and other fruits offered for sale must be washed in water containing dilute hydrochloric acid. That is considered a sufficient treatment to remove the poison. The government, however, does not have enough inspectors to watch the fruit on the market, and most growers do not have equipment for the treatment of their fruit. The safest plan at present is to use fresh fruit and vegetables and throw away the skins and outside leaves.

"Prepared with sulphur dioxide." Did you ever read that on the label? You had better read the labels. They are not very good protection from poisoning, but they are some protection. The United States has laws requiring certain substances to be named if they are used in the preparation of food. Some States have similar laws in addition to the Federal laws. There is some doubt how poisonous sulphur dioxide is when you eat it on dried fruit. If you do not want to see if you can die of poison, try your best to get rid of the poison before you eat the dried fruit. The sulphur dioxide is used to bleach the fruit. You know how an apple darkens when it is cut and laid aside. Other fruits, like peaches and apricots, darken even more. Some people seem not to like dark color on the fruits they offer for sale. Therefore they treat the fruit with sulphur.

Sulphur may not be very poisonous in the amounts present on the fruit. Experiments leave some doubt. Several European countries have prohibited the importation of American dried fruit because it contains too much sulphur. The government experts of those countries think it poisonous. If you like dried fruit, you would do well to get rid of as much of the sulphur as you can before eating it. Wash the dried fruit thoroughly in hot water. Then put it in a pot of cold water and bring it slowly to a boil, stirring occasionally. When it boils, pour off all the water. Never mind if you lose some of the juice; you probably lose some of the sulphur also. Then add some more fresh water and start the boiling process again.

"One tenth of one per cent of benzoate of soda." You will often find that on a label of a food container as, for example, a ketchup bottle. It sounds like a very small quantity, perhaps not enough to poison you. There has been much discussion as to whether one tenth of one per cent of benzoate of soda is poisonous. If you take it every day in fruit syrups, preserves, and a variety of other foods, it probably does you no good. Several of the large companies do not use it.

Dyed food. Did you ever read "Color added" on a food container? Some manufacturers seem to think we want our food gorgeous colors. Some dyes are definitely poisonous. In fact, certain dyes are used to kill bacteria. There is no good reason for eating dyes and there are certain dyes that are dangerous. Foods taste just as well without the coloring matter. In preparing many foods some of the natural color is lost, but that is no reason for adding unnatural color. In selecting foods that are labelled, it is just as well to choose those without coloring matter added.

Poisonous gas. Did you ever notice how the dining room silverware blackens? Perhaps you have had the job of rubbing that black off. Where did the black come from? Your fire was sending up fumes, and among the gases that came up was sulphur vapor. The sulphur unites with the silver and makes a black compound, silver sulphide. You polish the silver sulphide away and expose the bright silver again. If you do not enjoy polishing silver, you might study that fire. When it has enough draft so that sufficient oxygen goes into the fire box, the sulphur and other gases go up the chimney.

You breathe those gases turned into your living rooms. Some of these gases may be harmless, but others are definitely poisonous. Some sulphur gases are poisonous. Of course, they are weak in the air of your house, but the blackening of the silver is evidence of their presence; with continual breathing they may poison. If you have arranged the drafts properly on the fires and if you arrange the windows to get a little ventilation, you need breathe less of the gases. Did you ever notice how tired you get of staying in the house and school? Of course. It is not all just the restriction on your freedom. Part of it is poison gas. Look at the eyes of the people in your school building at the close of the day's work. Part of that tired, reddened appearance is due to gases. Our best systems of ventilation do not remove all of these fumes. When the warm days of spring come and the windows are open and the fires are slackened, you do not notice the tired, reddened, and watery eyes so much.

The most dangerous of the fumes from fires is carbon monoxide. You studied about this deadly gas in Chapter Eighteen. This poison gas is formed in our stoves and furnaces, also, when there is not enough air going into the fire or too much coal is heaped on.

It is especially dangerous in those portable gas and oil stoves that do not have pipes to lead the burned gases up the chimney but instead let them escape into the room.

When a home is supplied with gas for burning there is more danger. Very often small leaks occur at the joints in the pipes. Rubber hoses are sure to become porous and leaky. Small quantities of gas may continually leak into the house. If large quantities leak in you will probably smell it unless it is odorless natural gas. If you are asleep when the leak develops, you may never wake up, or there may be an explosion. Small leaks that you can just barely smell should be attended to at once. Various gases that constantly go into the house in small quantities from fires and pipe lines are poisons. Many of our little headaches and dull feelings may be due to these poisonous gases.

Beauty poisons. Those human beings who put cosmetics—"beautifiers"—on the skin run additional chances of being poisoned. Lead and arsenic are used in some cosmetics. They are both dangerous poisons. It is not safe to assume that because you do not eat them you will not be poisoned by cosmetics. Painters do not eat paint but sometimes get lead poison, painters' colic, and wrist-drop, merely from the paint that they get on their hands. Why rub it into your face? Mercury compounds are also used in cosmetics. Mercury is a dangerous poison.

Preparations used for removing hair that the ladies do not want are especially dangerous. One such preparation used a compound of thallium, a poison once used for rats, ground squirrels, and prairie dogs, and now considered so dangerous that it is not advised even for that use. See the doctor if you want unsightly hair removed. Buying "something" at the drug store is dangerous.



Haunted jars

Hair dyes are poisons. Lead, silver nitrate (used also for poisoning bacteria), mercury, and poisonous dyes have been found in hair dyes. With the present craze among certain women for changing the color of their hair, there is very great danger of injury that cannot be corrected. Some hair tonics also have been found to contain poisons, especially arsenic.

What can one do about the use of hair tonics, hair removers, and beautifiers when so much danger of poison is in their use? If you must have them, see your doctor. It may cost a dollar or two for his advice, but it will cost many dollars to treat the poisoned body. Sometimes the poisons of the "beauty treatment" have so ruined the skin that the woman must go through life disfigured.

How to Learn about Poisoning Your Body

I. Read the chapter.

II. Watch for poisons in food and drugs and in your home.

1. Read the labels on food packages and make a count of all the foods that are labelled "prepared with sulphur dioxide," "benzoate of soda," coloring, or other materials

which you do not recognize as harmless. Watch canned, and bottled goods and packages of fruits.

2. Similarly examine the packages of all toilet articles.

3. Search your home for possibilities of gas leaks and worn connections.

4. Similarly study the fires in your kitchen and in the cellar. Are there possibilities of fumes leaking into the house? Study the setting of drafts and the loading of fuels that are followed by odors and that are not so followed. Watch the silverware. Is there evidence that the fumes of sulphur are reaching the silver?

III. Answer these questions:

1. What poisons are found on fruits on the market?

2. How did the poisons get on the fruit?

3. How can you be sure that they are removed before eating the fruit?

4. What measures would you take to remove sulphur from dried fruit?

5. What dangerous fumes are likely to enter your home?

6. How can your home be protected from each kind of fume?

7. How can you often learn of the presence of poisons in package foods?

8. What toilet preparations are especially likely to contain poisons? What can you do about it?

IV. Think out these questions or investigate:

1. Is there any way of protecting fruits without the use of dangerous poisons?

2. Most white flour on the market has been bleached. Why is it bleached? Is there any bread on the market in your vicinity not made of bleached flour?

3. In what season and in what kind of weather does the air of city streets seem to be most contaminated by automobile fumes? How can you avoid breathing them?

4. In certain industries the workman must be protected from fumes and dust. How are they protected?

V. Vocabulary. Did you find any new words? What are cosmetics?



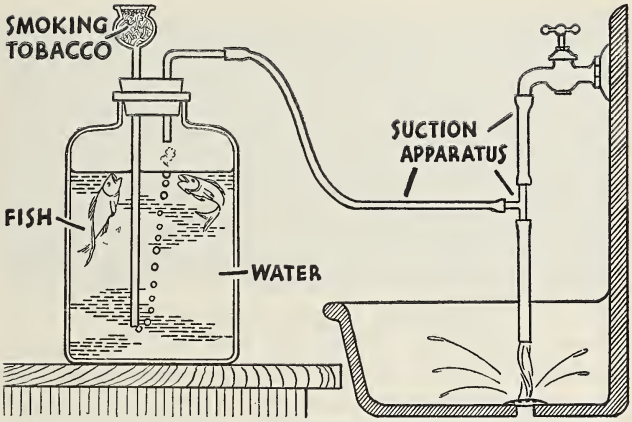
Philip D. Gendreau, N. Y.

CHAPTER THIRTY

TAKING POISON FOR FUN OR CURES

Tobacco poison. Nicotine, a poison from tobacco, is used to poison plant lice and other insects that collect on leaves and suck the sap. You can buy preparations of nicotine from seedsmen for that purpose. If you have plants in your garden or house infested by plant lice, spray them with nicotine and see how quickly the insects are killed. A spray that contains only five one-hundredths of one per cent of nicotine will quickly kill the insects.

If you are hard-hearted or hard-headed, hard to convince, you might be forgiven for experimenting on fish in an aquarium. Get some of the nicotine preparation from seedsmen and mix just a little, a quarter of a teaspoonful in the aquarium that contains a fish or two. Watch what happens. If you think that form of nicotine is not what a man smokes and therefore does not tell you what nicotine will do to a smoker, perhaps you can find a smoker who will blow smoke from a cigarette through a glass tube into the water of the aquarium. Then watch the fish. Take



A small amount of tobacco will kill fish

the fish out when you see that they are in distress and place them in fresh water.

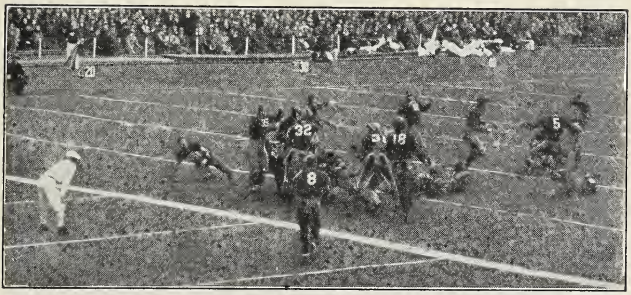
Even in man, the nicotine of the cigarette takes effect promptly. The pulse rises and the blood pressure is heightened. Then, if the man exerts himself, his heart labors to supply the oxygen that his cells need. He is short of breath. The coaches of athletic teams know that very well. Stop smoking or off the team you go. Indeed, a smoker has only half as much chance of making a team as a man who does not smoke. Records show that of the men who made the teams in the colleges examined, the number of men who were not smokers was twice as great as the number of smokers. At colleges and at schools, examination of records has shown that there were fewer smokers among the good students than among the poor students. Nicotine poisons the nerve cells, including those of the brain.

Nicotine is a deadly poison. The first smoke often brings headache and vomiting. That is the sign of

poisoning. The reason why it does not kill people immediately is that they get a smaller amount in proportion to their size than do the insects you spray with it. The body often becomes accustomed to small doses of poison. Then the small dose may be increased without killing. This is true of many kinds of poisons. But it does not mean that they are not poisoning the body. The shortness of wind, the quickened pulse, and heightened blood pressure are signs of poisoning. With young people such poisoning may be very serious. Examination of schoolboys has shown that those who smoke were only 90 per cent as heavy, 80 per cent as tall, 78 per cent as large around the chest and had only a little over half as large lung capacity as those who did not smoke.

The smoke after dinner that many smokers say gives them relaxation and rest, gives them the relaxation by poisoning the nerve cells and decreasing the activity of the nerve cells of the brain especially. The cells are too sick to care. They are just too stupid to be annoyed. But that the poisoning tells on the nerve cells has been shown by actual test in which the accuracy of muscular work was tested before and after smoking. Smoking resulted in a measurable loss of accuracy.

Another poison. Alcohol is an excellent poison for killing bacteria and other low forms of life. If you have a microscope or a good magnifying glass you can perform an interesting experiment by raising some tiny animals that are common in stagnant water. Put a little handful of hay or dead grass in a glass of water. It is better to use water from a pond or brook but city water will sometimes do. Let the glass stand for a few days or a week or two. Then, if your little water farm has been successful, you may find many very tiny white dots swimming around. They



H. Armstrong Roberts, Phila.

College coaches forbid smoking by their athletes

are little animals just about large enough to be seen with the naked eye. These little animals are called by their scientific name, *Paramecium*. They have no common name. Take out a drop of water containing some Paramecium and place it on a small piece of glass or microscope slide. Look at the Paramecium with a microscope or magnifying glass. Then as you watch them, put a small drop of alcohol at one edge of the drop of water. The little animals are instantly killed. Similarly alcohol kills bacteria, and the doctors use it to kill bacteria on instruments or on the skin.

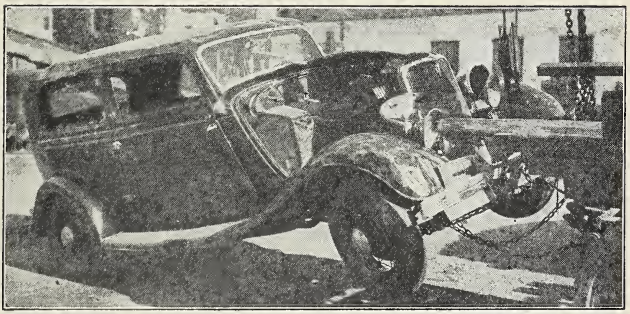
Your body is made up of very tiny living things called *cells*. They are living together in your body helping one another to live. Alcohol will poison your cells if it reaches them as it poisons the Paramecium. The cells of the human body are not instantly killed by the quantity of alcohol that reaches them from an alcoholic drink. But they are poisoned. And if the poisoning is continued, they are so badly damaged that the body is wrecked. Perhaps you have seen such persons, hopeless drunkards. Even a very small quantity of alcohol taken into the human body affects the living cells. Among the first cells to show the poisonous effects are the cells of the nervous system.

You can easily recognize the person who has "a drink or two." It is very evident that his brain cells have been confused. He talks in a way in which a normal person would not talk. He does things that he would not do if his brain cells were acting properly. You recognize the poisoned condition and avoid the person poisoned with a few drinks of alcoholic beverage.

In these days of automobiles, the person with poisoned nerve cells is dangerous. By actual tests in experiments in which drivers were given small "ordinary" drinks of alcoholic beverages their time of reaction and the accuracy of their movements and their accuracy of judgment were measured. Their response to signals was slower, although they knew that they were being tested. Their movements were clumsy and inaccurate as compared with their response when they had no alcohol. Their judgment of speed and distance was poor.

Suppose a child darted out on the street when such a driver was coming at forty miles an hour. Remember that this person was not drunk; he had had only "a drink or two." Or suppose an old person stepped off a sidewalk at a crossing. Or suppose another car crossed on an intersecting street. At forty miles an hour, a car will go over a hundred feet before you can shift your foot to the brake and bring the car to a stop. If the response of the driver is slowed even a fraction of a second by alcohol poisoning, it may mean the death of a person on the street or in a car. Remember this test was not one of "drunken driving." The drivers were not drunk. They had only had "a drink or two" and probably no one who saw them would have suspected it. They seemed normal, but their nerve cells were poisoned.

Tests of many varieties have been given to persons who had taken "ordinary" drinks of alcoholic



H. Armstrong Roberts, Phila.

Just another drunken-driver smash-up

beverages. They have been tested with typing, adding columns of figures, shooting at targets, and various other mental and physical operations. A "drink" brought loss of efficiency. In test of endurance also these persons who had been given mild alcoholic drinks, beer and wine, were inferior to those who had not. On days on which they had taken only one glass a half hour before the test, they were inferior to the days on which they had had none.

It is a common error that a bottle of beer will not hurt anyone. There is as much alcohol in a bottle of beer as in a small glass of whiskey. That quantity of alcohol has been shown by actual controlled experiment to reduce the accuracy of movement, the rapidity of response to a signal, and the endurance. The reduced efficiency lasts for several hours from a glass of beer, by actual test.

A deceitful phase of the alcohol poisoning from a glass of beer, wine, or whiskey is the feeling of cheerfulness and liveliness. It makes the drinker feel good. He thinks he is doing better in his driving, typing, or shooting when he actually is doing much worse. When shown the record, he may want to argue about it.

Alcohol has long been regarded as a stimulant, arousing activity, when its real effect in the end is just the opposite. It is a narcotic, putting the nervous system partly to sleep. A feeling of warmth may pass over the body because the capillaries of the skin have relaxed and the blood comes to the surface. The experience of men in cold climates has shown that there follows a dangerous chilling afterwards. The temporary glow is deceitful.

Besides the nervous system, other cells of the body are poisoned by continued use of alcohol. The systems that must labor continually to supply the substances to the body, the heart and blood vessels, are damaged. Similarly the organs that eliminate poisons from the body, the liver and kidneys, are damaged. The delicate tissues of the lungs seem to be so badly poisoned that pneumonia is more common among drinkers and they more often die from this disease than do those persons who do not drink. The alcoholic condition is well known by the doctors, and they know that the recovery from disease is handicapped by alcohol. Insurance companies are on the alert to detect the drinker who applies for insurance. He is not a "good risk." He probably will not live to old age. They want people whose bodies have not been poisoned.

Drugs that your doctor did not order. Were you ever given an aspirin tablet? The majority of people are not visibly harmed by that drug but some are made sick and some are killed. How many are poisoned to a lesser extent is not known. It relieves a headache sometimes, does it? And what else does it do to you? Many preparations sold in the drug stores contain aspirin without announcing it on the label. Aspirin is a poisonous drug. It may benefit you sometimes, but do you know before you take it

whether it will help or injure you? Who does know that? Well, the doctor probably knows as much as anyone about that. Better see the doctor.

Probably that headache will all be gone in the morning anyway. If it is not, then something is decidedly wrong. A pain is a friendly warning from nature that something is wrong. That wrong had better be righted before damage is done. The best person to find out what is wrong is the doctor. It is true that sometimes he has a hard time finding out what is wrong. Then what chance have you of finding out alone? The drug-store clerk is there to sell drugs, not to find out what is wrong with you. Indeed the law does not let him find out what is wrong and take pay for it. That is the doctor's work. The druggist is there to get you what the doctor says you should have. When you and the drug-store clerk try to prescribe poisons, it may be a serious matter for you.

There are a number of drugs that may be bought without a doctor's prescription and they may be very dangerous without the prescription. Cinchophen, although it may not harm some people, has killed others. It is a common rheumatism remedy. Many preparations sold for rheumatism contain it. It is another poison that you had better leave to the doctor. Acetanilid and acetphenetidin are also used in headache powders and they kill people. Many headache cures and "bracers" are dangerous. Headache is a symptom, not a disease. Find out why you have a headache, and do what your doctor says about the cause.

To Learn about Taking Poison for Fun or for Cures

I. Read the chapter.

II. Study about alcohol, tobacco, and drugs by observation and experiment.

1. Experiment No. 60. Try the experiment to show the effect of tobacco on fish described in the chapter.

2. Experiment No. 61. Add a half teaspoonful of nicotine preparation used for insects to water in fish bowl containing fish. Such preparation may be obtained from seedsmen or druggists.

3. Experiment No. 62. Spray nicotine preparation on insects, such as plant lice.

4. Try the effect of alcohol on flies by wetting a tuft of cotton with alcohol and putting it in a bottle, and imprisoning flies, ants, or other insects in the bottle. Try alcohol also on fish in an aquarium.

5. Experiment No. 63. Try the effect of alcohol on Paramecium as described in the chapter. There are many other tiny water creatures that will do instead.

6. Keep a record, from the newspapers, of accidents due to the influence of alcohol.

7. Look over the packages of remedies that you may see for the dangerous drugs mentioned in the chapter.

III. Answer these questions:

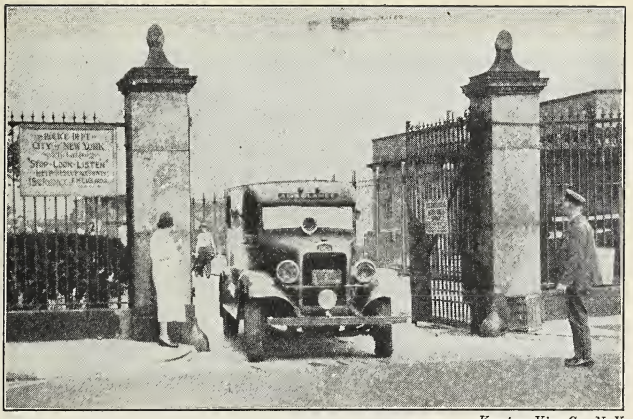
1. What evidence is there that tobacco contains poisons?
2. What effects have these poisons on the human system?
3. What evidence is there that alcohol is a poison?
4. Are beer and light wines harmless? Your reasons?
5. What is the bad effect of alcohol on the human body?
6. Why is liquor especially bad in this machine age?
7. What drugs often taken without a physician's prescription are dangerous?
8. What should you do for a headache?

IV. Think these out:

1. When you are tired what is a better way to get relief than to take a bracer?
2. The bracing effect of coffee is due to drugs it contains. What is another way to get similar effects?
3. What good does tobacco do the smoker?
4. Who should control the use of narcotics?

V. Vocabulary. Consider adding these to your list.

nicotine stagnant stimulant narcotic



Keystone View Co., N. Y.

CHAPTER THIRTY-ONE

WHY BE KILLED IN AN ACCIDENT?

Safe at home. Are you safe at home? An insurance company tells us that accidents at home cause the death of 31,000 people a year and injuries to 5,000,000. A loose rug on a smooth floor may shoot out when you step on it. If an old person falls in that way, it may mean a broken leg and the rest of life in bed, for sometimes old folks' bones do not heal when broken. If it is a child that falls, it may mean nothing more than a scare and discomfort, unless the child has something in its mouth or its hand. Then it may mean an injured mouth or eye. A loose rug at the foot of the stairs is particularly dangerous. A bucket or any other object left on the stairs may be as dangerous to an old person as a rattlesnake put into the bed. Many old people each year fall and are injured on stairs. An object of any kind left on the stairs may mean broken bones or death to young as well as to old.

A bottle of medicine or poison left within reach of children is about equal to a loaded gun left within

their reach. Leaving matches within their reach may result in a house afire or burning clothing and badly injured children. Knives and scissors are invitations to disaster. Children are great imitators. One tiny tot was found standing on a table preparing to shave with his father's open razor. A few minutes' delay in discovering him might have resulted in a cut jugular vein and a child bleeding to death.



An endless number of little things may mean injury to the person who does not notice them. A board with a projecting nail may give you lockjaw. Broken ribs from falls in slippery bathtubs are very common. Touching an electric fixture while in a bathtub of water has killed people. The water increases the current flowing through the wire and may increase it to a deadly current. A porch or stair rail carelessly mended may drop someone who leans against it. A turned-up rug or carpet may trip someone. A pair of roller skates or a bundle of books dropped on the floor may cause a fall and injury. A loose handle on a pot may slip out and allow a pot full of boiling water to scald the flesh on the legs and feet. A needle dropped on the floor and not recovered may be picked out of a bare foot, but bacteria from it may cause a bad infection. Ladders that slip injure many people.





The pictures on these pages may seem funny,

Use your head with tools and machinery. On a cold day a boy picked up an ax to cut wood for the campfire. He had kept on his leather gloves. At the first swing the ax slid from his grasp and laid open his brother's shin. Tools are dangerous if used carelessly. Often a knife slips and goes through a hand. Take thought. Ask yourself as you use the knife, "If it slips, what will it cut?" Always push the knife away from you. Sharp knives in the kitchen must be used with care. Watch. "What will it cut, if it slips?" Do not try to cut a piece of ice with a sharp ice pick while you hold the ice in the hand. You may get a bad stab in the palm of the hand. Put the ice on a board. A saw makes a painful cut if it slips. Where are your legs and other hand when you saw? "What will it cut, if it slips?"





Machinery is dangerous if you become drowsy or inattentive when you should be on the job. In spite of all the safety devices that the manufacturers put on a machine, the machine needs attention. A hand or a sleeve caught in a clothes wringer may mean at least a sore finger, and at worst, it may be crushed bones and flesh. Even sewing machines and lawn mowers have caused injuries. Machinery in industry is constantly causing serious injury and death.



but any of them might have been a tragedy



Ewing Galloway, N. Y.

State laws insist on the safeguarding of machinery. Notice protective screens.

In spite of all that designers and manufacturers of the machine can do and in spite of the safety measures of the management, men become incautious, especially when fatigued. The hours just before noon and just before closing time are the hours of most accidents in industry. It is not safe to operate most machines when fatigued.

Play safe. If you must play in the streets, and often there seems no place else in which to play, then do not get lost in your play. Remember that you are playing on dangerous ground. Like a squirrel in the woods, you must scamper about with the eyes and ears open for danger every instant. Something more deadly than a hawk may suddenly sweep down upon you. Cities and towns are learning to provide playgrounds, but there never will be half enough. Many cities rope off certain of the quieter streets during play hours. Play your part if there are play streets in your neighborhood. Use them, even if you



Philip D. Gendreau, N. Y.

A hazardous playground

do have to walk a little way. Before you dive for a ball that has been thrown into a danger street, look. The fellow behind the steering wheel may not see you in time. Do not dart out from behind a parked car; it is much like trying to outrun a railroad train at the crossing.

Look out! Over 967,000 Americans were injured by automobiles in 1936. In the World War 225,000 Americans were injured. In the World War 70,000 Americans were killed. More than that number are killed on our roads and streets in any equal length of time. What shall we do about it? What will you do about it? Well, if you are about to cross the street, or if you are walking in the road, see the auto first and do not wait to be killed. If you are in the automobile and not doing the driving, you just cannot do much about it.

In a busy street, there is no safe place to cross, but the most nearly safe place is the corner crossing, especially if it is guarded by a traffic signal. Even

if there is a traffic signal there, however, do not go to sleep when crossing the street. There are drivers, many of them, who cannot stop when the green light goes off. Keep your eyes open for those drivers and the kind that are in a hurry to make the turn before the light changes. Do not trust to Providence and the driver; look out for yourself and look quickly and constantly. Remember that parked cars are dangerous—when you step from behind them. If you must go out that way, stop and look first.

When you go swimming. A young man who was accustomed to swim a couple of miles from shore in Lake Michigan was rescued by a farm boy from a little river in Ohio. The young man was caught in the current, a thing he had never met in the big lake. He tried to swim out of the current, and wore himself out. He lost his head. If he had just stopped swimming, he would have been carried into the shallows in a few minutes. Do not lose your head, when things are not going the way you are used to. That is when you need your head.

A small boy was once trying to raise big stones from the bottom of a canal nine feet deep as the big boys were doing. He was a determined little fellow. He got down at the bottom tugging at a stone, until he ran out of breath. Then he stayed and tugged some more. Nature took command. He breathed in, but there was nothing but muddy water to go in. He came to the top with the stone. The big boys hauled him out and spent some anxious moments shaking the water out of his lungs. Know your limit and stop short of the limit.

When you are going to swim across the lake, have a boat go along with you. Never mind who swam the English Channel. Those swimmers had boats along too. If you want to swim long distances, swim

along shore, not straight across the lake or stream. If the water is too cold for comfort, do not stay in. It is no fun and may be a catastrophe. One thing more, do not go swimming after dinner. You may not make a beautiful corpse.

In the boat. An old canoeman said, "When you must change places in a canoe, don't." There is just one safe way to change places with another person in a canoe. Go ashore to change. There are drownings every week-end in warm weather. Boating accidents are not necessary. Boating and swimming are healthful sports, but they need to be enjoyed with common sense. It is not common sense to overload a boat or to lean over the side or to change places. Sit down in the boat. A boat is tippy if you stand up. It will throw you overboard before you can squat down. Do not take out into deep water any person who cannot swim. And as for the fool who rocks the boat, leave him ashore next time, if you have to knock him out first.

How to Study about Accidents

I. Read the chapter. Do not memorize any of it.

II. Study how to be safe by observation and thought.

1. Make a safety survey of your home. Look for the hazards suggested in the chapter and others you may see. Write down a list of them. Remove all those that you can remove yourself. Decide what you should do about others.

2. Watch the use of tools by the inexperienced and by the experienced workman. What are the chances of injury?

3. Look over machinery for safety guards and for danger spots unguarded.

4. Locate playgrounds and play streets about your town if you do not know them. How many parts of town are not provided with safe places in which to play? Make a

count of the hazards where you see children playing in the street. Count the number of automobiles that pass.

5. Make a study of week-end reports of accidents in newspapers. Determine, if possible, how the accidents could have been avoided.

III. Test yourself with the following questions:

1. Make a list of the common household dangers.

2. Why is it dangerous to touch electric fixtures when you are wet?

3. Write down a list of the common tools about the house and garden, and after each write how it may be dangerous in ordinary use.

4. What are the danger periods in industry? Why? What should the individual do about it?

5. Where are the safe places to play in the city? What precautions should you take when playing in the street?

6. Write down a set of rules that will, if followed, save you from death or injury from passing automobiles.

7. What are the chief dangers in swimming and how may they be avoided when enjoying this healthful sport?

8. Why are there many boating accidents every week end in warm weather? How may this sport be enjoyed without danger?

IV. Think about these questions:

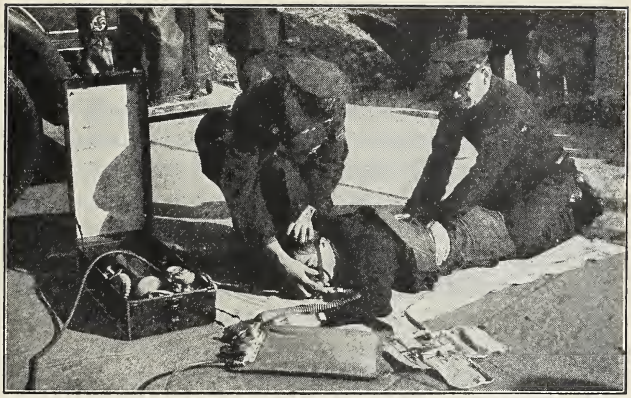
1. To what dangers are small children especially liable out of doors? What can you, yourself, dc about it?

2. Have you seen any action by pupils about your school that endangers others?

3. What do you do on a picnic that may lead to an accident? What can you do about it without making the picnic dull?

4. What has your State or city done to reduce the accidents upon the highways? Do you do your part to help prevent accidents on the highways?

V. Vocabulary. Did you find any new words for your list?



Ewing Galloway, N. Y.

CHAPTER THIRTY-TWO

WHAT TO DO IN ACCIDENTS

When you meet with a serious accident. When you meet with a serious accident the best thing to do is to get help. You may have some general idea what to do or you may know exactly what to do, but if the accident has happened to you, you may not be able to do it. You may be too badly injured to do it, or you may get excited and lose your head. You may not be accustomed to act in an emergency and "lose your nerve." If the injured person is one dear to you, your mother or your little brother, you may be so badly shocked that you seem to lose your senses. Of course, you want to "keep your head." Keep cool. Get hold of yourself. Sometimes that seems difficult.

Call for help. If your next door neighbor is at home and can hear, a shout of "Help" may be enough. Scream, not as a child at play but as one injured or in danger. Strangers may not respond to a child's screaming, but if your neighbor knows that you are not accustomed to scream uselessly, he or she will

come. Scream "Help," but never do so at play. If you see a stranger, but not your neighbor, scream, "Help me, help me." But do not do it for a trivial cause. Learn how to call for help on the telephone. If you can reach a telephone but do not know what to do next, tell the operator. Tell her where you live and what has happened. Be brief and in earnest. But do not call the operator for a minor injury. Call your friend or a doctor. Do not wait for your mother to come home or for your neighbor, if the accident seems bad. Learn to act for yourself in calling for help. A policeman will always help you. Almost anyone you see will help you in a bad accident.

Learn to act for yourself. The story comes from the Canadian woods of two boys, aged eleven and nine, who were left to take care of themselves for the winter in a cabin in the woods. Their father, as was his custom, had gone away to work in the woods for the winter. A railroad car fitted as a school had been placed on a siding fifty miles away. After their father had gone the two boys decided to go to school. They made their way through the woods, set up a camp near the school car, and stayed there all winter. The temperature was often thirty degrees below zero. They found their own fuel and food. They attended school. They had learned in the woods in their nine and eleven years to take care of themselves in the wilderness.

Another story comes from farm life in the State of Maine. A ten-year-old girl was left to take care of her little seven-year-old sister on their little farm in the woods when their mother and father went to town overnight to get supplies. The little sister in gathering eggs in the barn fell from a ladder to the barn floor. Her arm hit a scythe which sliced the flesh and sent a flood of blood over the child. The older

sister heard the child's screams and hurried to the barn. She found her little sister unable to rise and red with blood. The older sister kept her head. She commanded the injured child to lie still, ran to the house, grabbed a clean towel from a drawer, and hurried back to the barn. She bound the cut arm tightly with the towel, stopping most of the bleeding. Then she carried the little girl to her bed. She bound the arm tighter till she was sure that the bleeding had stopped. She stayed beside the little girl for an hour. She made the little girl promise again and again to lie perfectly still. She placed a glass of water within easy reach of her good hand. Then she set off on a tramp of eight miles through the woods to the nearest neighbor for help. She brought back the doctor. The little sister, true to her training in the woods, had not moved from the bed.

Are you able to take care of yourself in an emergency? Are you able to take care of your smaller brother or sister? Are you able to do the right thing if your aged grandfather falls and is injured when you and he are home alone?

What to do with a cut. First, wash your hands thoroughly with soap and water. If the cut is bleeding badly, stop the bleeding. The first thing is to notice how the cut bleeds. If the blood comes in spurts, an artery has been cut. Bind it tightly. If that doesn't stop it immediately, feel around just above the cut, that is, between the cut and the heart, press hard with your thumb. If you find that the bleeding stops you know that you have pressed an artery. Bind a bandage on tightly at this spot, putting a stone under the bandage, if necessary, to get sufficient pressure. You may need to use a tourniquet. To make a tourniquet, tie a handkerchief around the arm at this spot and twist it tight



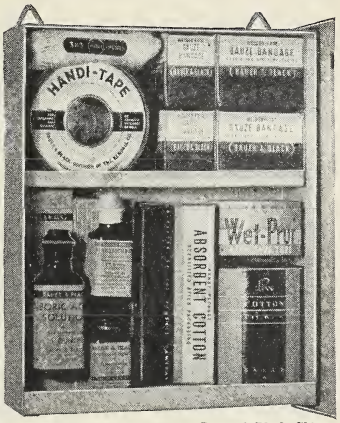
How to use a tourniquet

with a stick. Loosen the bandage in twenty minutes, because long pressure may injure tissues. If bleeding has not stopped, apply the pressure for another twenty minutes. Send for a doctor.

If the blood flows in a steady, heavy stream, it is a vein that has been cut. Bandage it tightly. Press below the cut if the first bandage does not stop the bleeding, that is, press between the cut and the end of the limb, on the side of the cut away from the heart. Send for the doctor, for bleeding from a large vein may be almost as serious as bleeding from an artery and requires prompt medical attention.

In small cuts, a bandage or tuft of cotton is usually enough to cause prompt stoppage. In small cuts there is more danger of infection than of a serious loss of blood. Put a drop of iodine on the cut to kill the bacteria. Then put on a clean bandage. A drop of iodine on the bandage will kill bacteria on the cloth. Do not put adhesive plaster directly on the cut, because it retards the healing. Put a little tuft of gauze or clean bandage on which you have put a drop of iodine. Then fasten the gauze with adhesive tape. Use clean bandage. Old handkerchiefs that have been thoroughly laundered and kept in a clean place will do if you have no bandage from the drug store. It is necessary that the bandage be sterile, that is, contain no bacteria. The drop of iodine will sterilize it.

What to do for a bruise. If you get a bad bump above or below the eye and do not want a



Bauer & Black, Chicago
What a first-aid kit should contain

"black eye," quickly get a lump of ice, break it up, and put the pieces in a handkerchief. Hold this ice bag on the spot. Never mind if it does hurt a little. Ice water, spring water, snow, or anything cold will do. Keep the handkerchief wet with cold water; dip it frequently in the cold water. But do it quickly. A bad bump frequently injures the tissues under the skin, and blood flows in. If you stop the flow of blood or of the liquid part of the blood into the injured tissue you will prevent swelling. Pressure and cold will help stop this internal flow.

What to do with a sprain. If you have twisted your ankle you know it hurts. If it is a bad twist, perhaps the ligaments are torn or tissues are stretched. There are three things to do. The first is rest. Stop moving the injured part. You often want to know if it still hurts and move the part to find out. This may tear the ligaments again. Keep off the foot or keep the hand in a sling. Cold cloths or ice bags may reduce the swelling and lessen the pain. The third thing to do is to see the doctor if the sprain does not cure itself in a day. If it seems bad, see the doctor immediately.

What to do with a burn. If the burn is slight, grin and bear it. If the burn is severe, the tissues have been injured, and a doctor must be called. If the burn is not covered with clothing, pour oil on it or anoint it with vaseline. If it is under the clothing,

the clothing must be removed from the burned skin. This removal must be done without tearing away the flesh which may stick to the cloth. It is better to leave this for the doctor. If you are where no doctor can be had quickly, the clothing should be soaked in warm water before you try to remove it.

The flesh is easily torn away with the clothing. After removing the cloth, keep the burn covered with oil until you get help. When flesh is burned the destruction forms poisons which injure the whole body. For that reason, as well as for the treatment of the burn itself, a doctor's services are necessary. Keep the patient still and in bed until the doctor comes.

What to do for choking. Keep your head, if something sticks in your throat. Stop gasping. Although you may not be able to breathe freely, if you are getting some breath, you will not choke to death. When you have gotten control of yourself, bend away over and cough violently once or twice, but do not draw your breath in violently. If that does not dislodge the object, get help. If your little brother or sister chokes on some food that he or she is eating too fast or on a marble that is in the mouth, bend him or her over and slap on the back several times. If that does not bring relief, hold the little one upside down and slap the back again. Sometimes you may be able to reach in with your finger and get hold of the object. If that does not bring relief, quickly get help.

Something in your eye. Rub the other eye. That may start tears flowing and wash out the something. If it does not, try the next best thing. Lift the eyelid over the other lid. Turn your eye up, down, and around in a circle. That sometimes removes the object. Before you start into the eye after the object, get a clean handkerchief. It is



This is the best position for a person who has fainted

better to have someone do it for you. But if you are alone in the house, you may often do it yourself. Be sure that the handkerchief is clean. You do not want to infect your eye with disease germs.

When a person faints. You have heard that you should dash a pitcherful of cold water in the face. That messes up a pretty dress and is not necessary. Lay the person down, with the head lower than the body, if possible. Fanning the patient helps recovery; plenty of air is better. The person faints because the heart does not send the blood to the brain. If you lay the person down, the heart has an easier job. If you get the head lower than the body by tilting up the foot of the bed or couch, it is still easier for the heart to get blood to the head.

What to do for nosebleed. Keep still. Sit upright; do not lie down. Have someone get you a handkerchief wet with ice water or a piece of ice and put it on the nose and face. Sometimes a little shock like a cold key dropped down the back will stop the bleeding. A handful of salt mixed in a glass of cold water and snuffed up the nose, will sometimes stop the bleeding.

What you should do with broken bones. Nothing. Unless the person is in danger of traffic or of catching pneumonia, let him lie where he is and get the doctor. If he must be moved, first tie a wad of clothing and a stick around the leg and tie it tightly

so that the bones cannot move and cut their way out through the flesh. That may be very serious. If the arm is broken, have it splinted, that is, tied to a stick so that it will not move and allow the bones to cut the flesh. Put the arm in a sling. Then get a doctor immediately.

What to do for persons taking poisons. A poison bottle usually has, and always should have, on the bottle the antidote, or substance which should be given to neutralize the poison. Follow the directions. Get the doctor immediately or get the person to a hospital. If acid falls on your hand, quickly get it under flowing water. That is the one best thing to do.

How to Study What to Do in Accidents

In this chapter were given only a few directions of what to do in a few of the many kinds of accidents that happen. A good way to study the subject further is to get a Red Cross Manual or a Scout Manual or a book from the library and go over it carefully in class, practicing the measures as far as you can. Read the chapter in the same manner in class. Read what to do with a cut. Then with bandages, gauze, tourniquet, soap and water, practice the art of placing bandages, after you have washed your hands clean.

I. Have a doctor or the teacher show you how to turn the eyelid inside out to look for something under the lid. Practice putting on splints, as on a broken leg and a broken arm.

II. Test yourself. Cover up the discussion in the chapter with pieces of paper, leaving only the headings visible. Then tell what you would do in each emergency mentioned.

III. Vocabulary. Suggestions:

adhesive tourniquet sterilize neutralize



UNIT IX

WHEN SPRING COMES

HAVE you seen the first bluebird and the first robin come back in the spring? Have you seen the first buds open on the maple? Have you watched the bright spring sun rise earlier and earlier each day and linger longer and longer each evening? As the evening came on and the chill came with it after a bright day of early spring, have you come upon a garter snake, now stiff and chill? Have you seen the fish come into the shallows to spawn? Do you know the joy of lying on your back with a fishing line dangling in the pool, or the joy of rambling through the spring woods and fields looking for anything that will turn up? Do you know the fun of just loafing under a tree and watching the birds and the bugs, active and restless, singing, hunting, darting about?

Do you know how the bird or the squirrel or the fox stakes out a claim to his hunting ground and drives off trespassers? Do you know why they are especially ready to fight for their rights in springtime? Do you know where the bumblebee and the dragonfly come from in spring?

Do you know what a flower is and why it is made? Is it for your enjoyment? If a flower blooms where no person sees it, is it a waste in nature? Do you know that plants use the same food, in part, that you eat? Indeed, we might better say that you eat the plant's food. Do you know where the plant gets its food? Perhaps you think that it gets its food from the soil. It does not; it makes its food. We shall study about it in this unit. Where do wild

things go when they die? How do they get there? We shall see. We shall see what good dead things are.

Did you ever see a tree? Really see it? See the buds open in the spring and see what is inside a bud? See where the seed comes from and why? Can you tell a tree's age? On a picnic you gather under the trees. Do you do anything to make good trees grow? Do you plant trees where you can? Why not? Learn how to select a tree for planting and how to plant it and care for it.

We are just beginning to see the value of forests. We have not seen very far ahead in this country. We are destroying forests seven times as fast as they can grow. We do not know how we shall get along when they are gone. You may think that will not bother the people now living in the United States, but that is a shortsighted view. Your parents are now paying for the destruction of forests needlessly. When you buy lumber that has been shipped three thousand miles, you pay the freight. New York and Boston now buy lumber grown in Oregon and Washington. Forests were once right at their hands. They were destroyed without need. The governments are slowly bringing back forests on land that will grow nothing else profitably, but meantime the hills and valleys of the Far West and the South are still being rapidly and wastefully cleared of their forests. We need the wood, but a great part of the wood is wasted. We do not need to waste good trees, and we do not need to destroy the forests. Let us see how we may use the forests and keep them.



H. Armstrong Roberts, Phila.

CHAPTER THIRTY-THREE

HOW SPRING STIRS THE WILD THINGS

Life astir. Now it is spring again. The days are long and the sun is bright. The showers come and clear away. It is good to be out in the sun and the breeze. It seems good to the birds too. They are everywhere. They are singing and flitting in the sunny treetops and bushy tangles. It is good to the squirrels and ground squirrels. They are scampering about, chasing one another, or scolding you for intruding in their woods and fence corners. It is good to the bees. They are humming about in the sun and busily working in the maples and willows or in the flowers on the ground. Even the snakes and the lizards may be out lying on rocks and logs in the sun, ready to snap up the living dinner that unwarily comes near, although, if the day is cool, they may be too stiff and stupid to bother. The frogs and toads are singing their love songs in the pools. The ground hog is up again from his winter sleep, hungry and alert, on the top of his burrow looking at you, or dashing from the clover patch for his underground safety.



The large, food-stored roots of the dandelion and narcissus make them early bloomers

Plants too are bursting into life. The pasture may be green with grass or gold with dandelions. If you dig out a dandelion, you will see why it can burst into bloom so suddenly even on a warm day in winter. Its thick root is filled with food, ready to supply the expanding leaves and flowers as soon as the sun warms the plant into activity. The bulbs of the spring beauty and of the tulips and daffodils in your garden similarly are filled with food to send the early flower stalk above ground and supply the expanding flower and leaves with food.

Some of the maples and the elms have perhaps already shed their early flowers and now are festooned with young fruits. The food which supplied their growth was stored in twigs, trunks, and roots. It was such stored food in the maple trunks that the maple sugar makers collected in February. The food laid up the summer before supplies the early spring flowers, leaves, and new shoots.

Each on the business of life. Sometimes squirrels and birds seem to frisk and flit about idly and joyously. You have seen swallows and pigeons apparently circling around just for the fun of it. Sometimes

a squirrel, like a dog, seems just to dash here and there because he feels full of life. Among larger creatures, horses let out into the pasture often gallop about and roll over on their backs just for the enjoyment of freedom. Bears are seen to indulge in playful antics, tossing things about.

Generally, however, the running here and there, the climbing and chasing, the singing and tumbling about, the peeping and nosing into holes and tangles, are part of the serious business of life. The great host of birds that one meets on a morning walk in spring are on their way to distant lands and waters. They have flown during the night on their long journeys. Their flitting about the trees is in search of food. Little flocks that are exploring the branches and twigs are searching for insect eggs and cocoons. The little flocks of sparrows in the grass are searching for seeds. Their incessant little musical calls are rallying calls to keep the little flocks together. While they are together they are safer from the sneaking and the swooping enemy. Some eyes in the flock will probably see an enemy approach. Then a little cry of alarm will send the flock flying to safety amidst the brush tangles or the treetops. If you approach a feeding flock, you will hear the little contented chippings suddenly interrupted by a cry of alarm, and away they go.



Hugh Spencer, Chester, Conn.

The fruit and blooms of the maple

Why a bird sings. In the Northern States no birds are more welcome than the robins in spring. The first robins

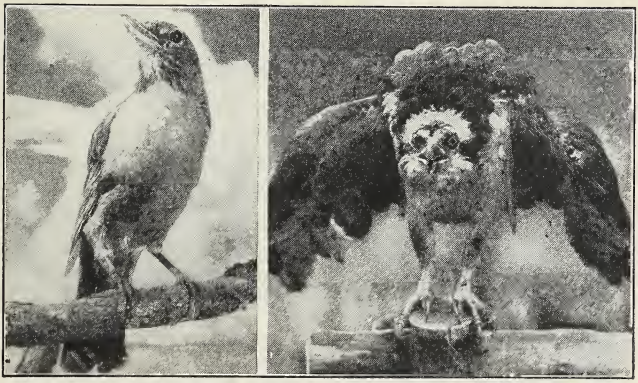


Ewing Galloway, N. Y.

These migrating birds are guests of the city of Oakland

to return are the males. You can always tell the male robins by their brighter colors. You will see a little band of two or three dozen moving along the trees of the creek bank and open hillside. Now they are on the ground searching for food, now they are up and in the trees calling, looking, and then dropping down again. By short stages they move along and away.

Some mornings later you hear a robin singing vigorously in a treetop. Not far away is another and at intervals on other treetops other robins are singing. But they are not singing in the same treetop. The singing is part of the serious business of spring. Each old male robin is announcing to the world that he lays claim to that part of the earth as his hunting and nesting ground. If another male robin comes within his claim, the song stops, there is a swift swoop down at the intruder, a sharp battle, much screaming, and one retires to unclaimed land or to land from which he can drive out another claimant. After some days or weeks of this establishing of claims by the males, the females come up from the South, and each finds a home ground prepared for her. Then comes the serious business of nest-building and rearing of young. It is fascinating. Watch them. It takes only patience.



Ewing Galloway, N. Y. *Philip D. Gendreau, N. Y.*

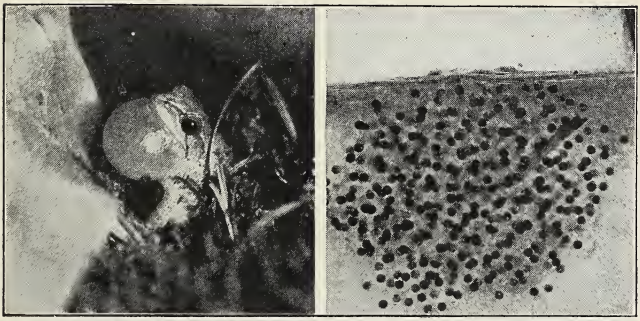
The singing robin and the charging fish hawk are each establishing their claims to a feeding area

Each on his own ground. The squirrels and chipmunks similarly search out hunting and nesting grounds from which they drive away others of their kind. Strangers are not welcome. Much of the scampering and chasing about that we mistake for playing in the springtime, is battling for a place on the earth to live and raise a family. If you live in the city you can see it among the sparrows and starlings, if they have invaded your city. Even each pigeon establishes a little parade ground about his nest from which he drives his neighbors of the flock. A strange dog wandering into a neighborhood is set upon by the earlier occupants, and the stranger establishes his claims only with his teeth. Your dog drives others from his own yard. The music of the alley cats at night tells of trespass and adjustment of claims by the law of the jungle.

Springtime along streams and pools. In the pools and streams life is teeming again. Indeed, one could find plenty of life in the streams all winter, even

if the ice had to be broken to find it. But now there is more. The kingfishers are back on the limbs above the stream, and you may see one splash into the water to arise with a fish or crawfish. You may see a heron standing at the water's edge or stalking very slowly along searching for his frog. If you go blundering along, crashing through dead sticks, you will only see the kingfisher flashing up the stream and the heron flying slowly and heavily to more lonely spots. You may get close to the phoebe perched on a limb near a bridge under which it will build its nest. It sits erect, occasionally giving a little double call that gives the bird its name, twitting its tail, and now and then slipping off its perch to snap up an insect you did not see. It has little fear of you. It is so close that you can hear the snap of its bill. About the tall dead grass and the bushes of the stream banks are song sparrows and wrens.

In the pools the frogs are singing their persistent and monotonous song. Even in a warm spell in winter you may sometimes hear the "spring peepers," the little tree frogs that start the spring chorus. Later other frogs come to the same pools, and the toads come also. Even the wood frog that spends the rest of the year far from water and the hoptoad of our gardens return to the pools in the spring. There they hatched from the eggs in the water and there they return to lay eggs. The songs that you hear are the males singing for their mates. When they sing they fill their throats with air until they look like bagpipes. If you search the pools in the spring you will find great masses and strings of little black eggs, each egg surrounded by a little ball of clear, colorless jelly. If you gather some of these eggs and take them home in a tin can they will hatch out. Then take care of the little tadpoles. Put plenty of water plants in their



Hugh Spencer, Chester, Conn.

A frog "singing." Frog's eggs.

aquarium, for their food is the little green scum of simple plants, the algae, that grow on the larger plants and stones under the water. When the tadpoles grow to be frogs they stop eating vegetables and must have insects and other small living things for food. If you cannot take care of them then, take them back to the pools and let them live their own lives, or serve as food for other wild creatures, for that is the way of nature.

What a wealth of life there is in the water! Little oval whirligig beetles, looking like black seeds, go swimming around in circling droves as you look over the brook bank at a quiet pool. Long-legged water striders skate away as you approach, but they do not go far and soon come back. These insects could be found in warm spots all winter. Diving beetles go to the bottom as you look. Crouch down at the water's edge and you can see them crawling along the dead sticks and plant trash on the bottom. But you must be patient. Crawfish (or crayfish) are out again from their winter burrows. You may see a sunfish scraping out a little nest in the gravelly shallows. And there are always more and more things to find.

Things to Do in Learning How Spring Stirs the Wild Things

I. Read the chapter.

II. Study nature by observation.

1. Go out in the fields and woods or into the city parks. If you cannot do either at present, make a springtime scrapbook of pictures of things which you plan to see on your first trip to the woods and fields.

2. Dig up a dandelion by the roots, and see why the flower can open so early in spring or even in the warm days that sometimes come in winter.

3. Gather twigs of trees and shrubs and bring them indoors to open. Find what is in the bud of each. Watch in the fields, parks, and along the streets for the opening buds, and keep a calendar. Watch for the development of fruits of maples, elms, and other trees. Enter them also on your calendar.

4. Get a book from the library that pictures and names the common birds of your neighborhood. Learn the names of the birds as you meet them in spring. Put them down on your calendar. Tell the number of each kind of bird you see in a day. Even in the big cities you can see birds in the parks and along the streets. Add bird pictures to your scrapbook. Under each picture tell in what kind of place the bird lives and what its food is. You can find out from watching the birds and from books.

5. Similarly list the animals and insects that you see.

6. Tell what the animals and birds and insects are doing when you see them: hunting food; building homes; apparently playing. Even the English sparrows, starlings, the stray dogs and cats of the city streets are worth watching. How do the squirrels in the park get their food? What do they find? Where are their homes? Perhaps you think they live in hollow trees, but do they? Where do the starlings get food? Where do they nest? What does the alley cat eat? Many other questions of wild life in the cities may be asked and some of them answered by observations.

7. Study the life in the water in spring time. Write down the questions that might be answered and then go out and find the answers. Bring in some frog's eggs and watch them develop into tadpoles and then frogs. Put plants in the aquarium with the tadpoles. They will find their own food if the plants live. Do not clean out all the green slime from the aquarium. When the tadpoles turn into frogs, you will need to feed them insects, worms, and bits of meat held in forceps or on a wire in front of their noses. If you cannot take care of the frogs, take them back to a pond where they can take care of themselves.

8. Study some of the smaller life in the water as suggested in the chapter. Make little drawings of the kinds of things that you find, with their names and notes on what you have learned about them. Or make a scrapbook of what you hope to find some day. If you cannot find pictures to cut out, draw some from pictures in books.

III. Think out or investigate:

Many things are suggested for investigation in this chapter and in the questions in Group II. You can think of many more. Here are a few suggestions.

1. Does the same English sparrow or starling or the same song sparrow stay in your neighborhood all year or are the winter birds from another place? Do the same birds come back to the same yards and orchards each year? Look up what has been found by bird-banding and tell the class.

2. You usually do not find red squirrels and gray squirrels in the same patch of woods. Does the red drive away the gray or the gray drive away the red? You may find something interesting by watching or by reading nature books and magazines in the library.

3. Are there any wild animals about your house, store, or barn? Mice, birds, insects, others? How do they solve the "problems of life"? List the problems and find out.

4. You have the same problems of life as the wild creatures. What are they? How do you solve them or how does someone solve them for you?

IV. Vocabulary. Did you learn any new words?



Ewing Galloway, N. Y.

CHAPTER THIRTY-FOUR

THE WORK OF THE FLOWER

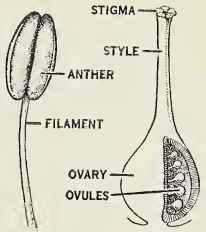
How a flower is built. Examine a spring flower. Notice outside the green leaflike parts that protected the flower when it was a bud. [This part is called the *calyx* and its parts are the *sepals.*] The showy bright colored part you see first is also seen by the bees. [This part is the *corolla* and its parts are the *petals.*] Bees need flowers and flowers need bees. The bright display is for insects. The flower has other things for the bees. There is perfume to attract them, and when they arrive, there is sweet nectar from which they make honey. Put your finger inside the flower and then look at the finger. You will probably find a little yellow or white dust. The dust is called *pollen.* (Remember the name.)

Pollen is important to the flower. It is important to the bees, too, for from it is made beebread. Notice that the dust comes from little knobs on the top of tiny stalks. [These stalks and their knobs are called *stamens.*] The bee gets pollen on her



The upper picture shows the parts of a flower. Below it at the left is a magnified bit of leaf. The stomata are the air passages through which the plant "breathes." At the right is shown how corn is fertilized by pollen falling from the tassel to the silk. At the bottom of the page are various fruits.

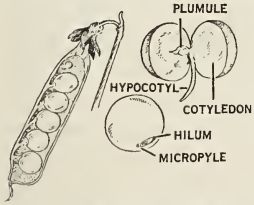
body as she reaches for the nectar. When she visits the next flower she rubs off some of the dust on a part of the second flower. [This is the *stigma* on the top of the pistil.] Examine the innermost part of the flower. It is called the *pistil.* (Remember the name, *pistil.*)



Stamen and pistil of a flower

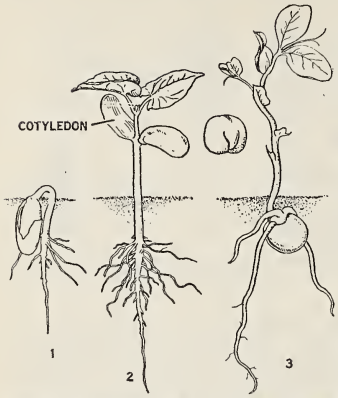
A flower's work. The work of the bright part of the flower is to get the pollen carried over to another flower and to get some pollen from another flower. After it receives the pollen, the bright-colored part of the flower fades. Its work is done. But there is work for the pollen and for the *ovary* at the bottom of the pistil. (Remember the *ovary.*) If you open the ovary with a knife point or a pin, you will find tiny seedlike bodies inside it. The pollen starts these bodies growing into seeds. The pollen also starts the ovary enlarging as the little seedlike bodies grow. The ovary protects them and gives them nourishment. The ovary grows to be the *fruit.*

Insects and wind help flowers. The bees thus have work to do for the plant. Their work is to carry the pollen that starts the seed and the fruit. Apple growers often put hives of bees in the orchards to make sure of a good crop of fruit, for there must be insects to carry the pollen. Bees are the most trustworthy workers for the apple flowers.



Fruit of a pea. The plumule will develop into leaves, the hypocotyl into a stalk and root. The hilum is the spot where the seed joins the pod; the micropyle is a tiny hole.

Bees thus are very helpful insects to mankind, not only



Seedling plants. 1 and 2 bean, 3 pea.

for the honey and beeswax which they make, but for the service in carrying the pollen from flower to flower. Without this service, we should be without apples, peaches, pears, and many other fruits.

Some flowers do not trust to insects to carry their pollen but trust to the winds. In the springtime you will find many grasses with little feathery tops. These tops are flowers that scatter pollen in the wind and collect the pollen they need from the wind. Many trees also scatter the pollen to the wind and collect the pollen of other trees of the same kind from the wind.

What is a seed? If you look in the springtime at the soft ground under your feet, you may see tiny plants just pushing up two rounded leaves into the light as in the picture above. They are the seed leaves (cotyledons). If you open a bean seed you will find them inside. They were already formed last fall. If you gently spread apart the two little seed leaves and look inside you will see a tiny point which is the bud ready to grow into a stem. You will also see inside the seed a tiny beginning of a root.

If you have peas or sweet peas growing in your garden you will not see the rounded seed leaves pushing above ground. They stay buried below and send their stored food up to the growing stem and leaves as shown in the picture above.

In the seed a little plant already formed has been waiting all winter. This little plant grew in the

flower of the parent plant last summer. As it lay during the winter wrapped around with its seed coat, the bud of the stem was ready to shoot upward with the first warmth, the root was ready to push downward, and the little seed leaves lay ready either to unfold or to send their stored food to the growing stem, leaves, and root. The parent plant during the last spring or summer furnished the nourishment for this young plant to grow to its winter size before the winter set in, and furnished in addition a supply of food to start it on its journey in life the following spring.

Things to Do in Learning about the Work of the Flower

I. Work through the chapter with the book, the flower, the bee, and, if possible, a microscope in front of you.

1. Study the structure of the flower. Read the book, examine the figures, and find the structures in the flowers. Make a drawing of your own, as simple as you like, showing the parts of the flower that you have. Label the parts as in the diagram.

2. If you have a microscope, touch the slide to the pollen and examine it under the microscope. Examine the pollen of as many kinds of flowers as you can find. Make little sketches in your notebook of the different pollens.

3. Watch the bee and other insects visit flowers. Where do they alight? Is the flower built so that they may alight easily, and are there structures that guide them to the nectar? How does pollen get on their bodies? Watch bees brush back the pollen from their bodies when they come out of the flower. How do they do it? Where do they store the pollen to carry it? As the bee enters another flower, how is the pollen placed on the top of the pistil?

4. Examine a bee, dead or alive. Where does the pollen stick to its body? Where are its "pollen baskets" in which it carries pollen to the hive? Look at its feet. How are they fitted to cling to the flower?

5. Search for grass in bloom and find the parts as shown in the diagram.

6. Soak some seeds—lima beans and peas—overnight. Then take them apart and find the parts shown in the diagram.

7. In Chapter Seven last autumn, you studied the fruits. Look back, if you have forgotten, and learn what good the fruit does the plant.

II. Test yourself with the following questions:

1. Take new flowers or cover the labels in the diagrams with pieces of paper and name the parts shown.

2. How does the pollen reach the top of the pistil in each flower shown or found?

3. How does the flower serve the plant?

4. How can you tell a wind-pollinated flower from an insect-pollinated flower?

5. Where does the seed grow to be a seed?

6. How does the seed serve the plant?

7. Where does the fruit grow to be a fruit? What part of the flower becomes the fruit?

8. What good is the fruit to the plant?

III. Think out the answers to these questions, or learn by investigation:

1. Do all insects that visit flowers, pollinate them? Do any other animals pollinate flowers?

2. Besides seeds, in what other manner do many plants produce new plants?

3. What is planted to get a crop of potatoes? of corn?

4. Most plants produce far more seeds than will grow to be new plants. How does this great number benefit the plant?

IV. Vocabulary. Many scientific words are needed to name the parts of a flower and their work. Perhaps you have found some new common words. Ask your teacher if you should learn the words in parentheses.

(calyx)	(petals)	(stigma)	fruit
(sepals)	pollen	pistil	seed
(corolla)	(stamens)	ovary	



Ewing Galloway, N. Y.

CHAPTER THIRTY-FIVE

THE BEGINNING AND THE END OF FOOD

Getting things from the soil. If you dig carefully, you may be able to take out a plant from the soil. If you carry this seedling plant to a brook and wash away the soil, you can see the young roots, delicate and fine, that clung so tightly to the little particles of soil. If you do your digging and washing very carefully, you may see tiny threads making a kind of wet fuzz on the roots. They are the *root hairs* that do all the drinking for the plant. You can see the root hairs better if you sprout some radish seeds on wet paper under a glass (Experiment No. 64).

All things in the soil that the plant takes, must go in through the root hairs, and all must be dissolved in water. The plant cannot get its soil minerals until they dissolve. Water seeping through the soil dissolves soil minerals. The soil water with its mineral content passes through the walls of the root hairs and so into the cells of the delicate roots. Plants take in large quantities of water. After it has done

its work it evaporates from the leaves as you learned in Chapter Eight (transpiration).

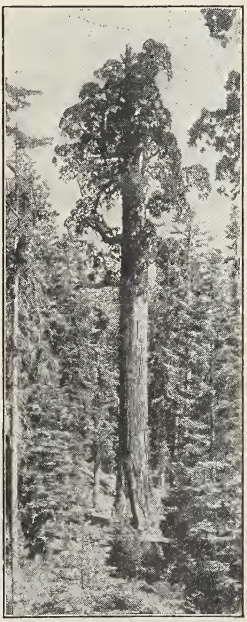
Making food. Upward go the water and minerals through the roots and into the stem, upward still through the stem into the leaves. The tree must send the minerals dissolved in water up to the leaves, though they be a hundred or two hundred feet from the ground. The minerals can do the plant no good until the green leaves are reached, for minerals are not food for the plant. They are part of the raw material out of which the plant makes food. The leaves are the food factories. To the soil water that roots and stems have sent them, the leaves add carbon dioxide that they take from the air. From water and carbon dioxide the leaves make starch. Then they add the minerals to make proteins. They often make so much food that they have far more than they need. The animals take the plant-made food. If it were not for the plants, the animals and men would starve to death. Plants make the food for the world.

Plants eat and work. After they have made the food, the plants eat it or some of it. They use it, just as animals do, to build their bodies and repair their cells, and to get energy. For plants need energy, just as animals do. They must carry the soil water to the top of the plant, even to the top of the tree, and that takes energy. If you have carried a bucket of water up as high as a house you know that it takes energy. A tree carries several tons of water up that high each year. Then, as with animal cells, it takes energy just to stay alive.

Plants must have air. Plants get energy by oxidizing food just as animals do. In their leaves are microscopic holes through which the oxygen enters. When they oxidize the food, they produce carbon

dioxide just as animals do. This gas must be passed out just as in animals. Plants have no lungs. Their breathing is slow, but they do not hurry around as most animals do, so that their breathing is fast enough for their needs. To be absolutely accurate, perhaps we should not say plants breathe, for they do not draw in the air as animals do and then push air out again. Oxygen from the air passes slowly in through the microscopic holes, and carbon dioxide at the same time may be passing out. (See page 319.) [This slow passing of the gases is called *diffusion*.]

Life lives on life. Over the meadow in the springtime the green plants are fairly rushing with growth and making food, and among them the animals are wandering, taking their food. Cows are taking plants by mouthfuls and so are the caterpillars. Mice are gnawing away their roots and bulbs, and slow-creeping black snakes are gently gliding among the tufts of grass to flash their heads suddenly forward and sink their fangs in mouse, toad, or bird. Toads and birds, in their turn, are searching for beetles or flies or moths or caterpillars. Other birds are searching for seeds and buds. Perhaps you will see still other birds sailing over the meadow to make a sudden swoop downward and seize a mouse, a snake, or a smaller bird. Life destroys life to live.

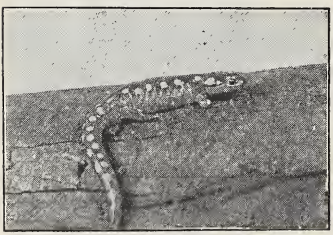


Underwood and Underwood, N. Y.

This tree must carry water 272 feet to its topmost branches

Up in the woods near by the same play of living and taking life is also being enacted. Small birds are searching the trees as we saw them in the fall for insect eggs and cocoons. Others are searching the ground for their insect food. Others still are catching insects on the wing. Seed-eating birds are exploring the ground, the weeds, and the trees, finding newly-formed seeds and those left from last summer, scratching for the sprouting seeds, and picking out the opening buds. Rabbits are hiding in the thickets and brambles until the shadows of evening are long, when they venture out for clover and tender grass. As the night falls, mice are hunting about the roots and the stumps. The prowlers like the owl, the weasel, the skunk, the raccoon, and the fox, come to take what they can kill.

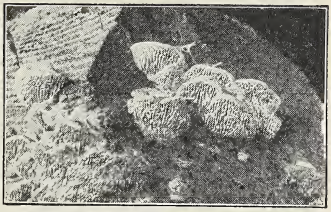
Over them all stand the trees of the forest, offering homes, hiding places, and shelter from storms. Birds, squirrels, wood mice, and many other creatures find homes in their branches, in their hollow trunks, and about their roots. Beneath their shelter grow the delicate wood plants that the open sun and wind shrivel away, delicate ferns and woodland flowers and thin-leaved mosses. Hiding among the dead twigs and leaves on the ground are little creatures by millions, beetles, ants, and myriads of other insects. Little red or black newts lurk under fallen bark and about the roots, snapping up now and then an insect or a small worm that ventures out from its hiding.



Hugh Spencer, Chester, Conn.

Newts live among fallen bark and leaves

Feeding on the dead. All these get their livelihood in the forest, and



Hugh Spencer, Chester, Conn.

This fungus draws its nourishment from the rotting stump

when they die their bodies return to the forest. On the dead live another host of creatures. Insects and worms feed upon dead animals and dead plants. Mushrooms and other fungi draw their food from dead trees, leaves, dead animals, and wastes. Greatest among these feeders on the dead are the smallest known plants, the bacteria, too small to be seen without a good microscope. All these destroyers of the dead change the dead plants and dead animals back to the minerals of the soil. They steadily enrich the soil by returning to it the minerals which the green plants took from it.

The mineral substances travel from the soil into the green plants, perhaps then to be eaten by animals and become parts of their bodies, then in the dead plants and animals to serve as food for fungi and bacteria, and so to return to the soil again. So the minerals go around and around through a cycle, or circle, from soil to plants, to living animals, through dead animals to bacteria and fungi, to soil again. So the cycle continues through the ages.

Things to Do in Learning about the Beginning and the End of Food

I. Read the chapter.

II. Study by observation and thought how plants and animals live together.

1. Find the root hairs as directed in the first paragraph of the chapter. EXPERIMENT No. 64. Grow radish seeds or other small seeds as directed.

2. If you have a microscope, strip a bit of the epidermis or skin from the lower side of a leaf. Some leaves strip very easily. Try different kinds until you are successful. Examine the bit of epidermis under the microscope. Look for the microscopic openings (called *stomata*) through which the gases pass in and out of the leaf.

3. Go into the woods or in a field and list living things that you can find, and with each tell what food it eats. Which feed upon living things? Which feed upon dead things? Which feed upon neither?

4. Could there be animals on the earth if there were no plants? Could there be plants if there were no animals? Does a lion depend upon plant food?

5. How do seaweeds get air? Where do they get their minerals?

6. Are dead plants and animals good or bad for the forest?

III. Test yourself with these questions:

1. By what structures do plants get minerals from the soil? In what condition must the minerals be in order to get inside the plants? Can a plant take dry minerals?

2. Where are the food factories of the plant? Out of what substances does the plant make food?

3. Where do animals get food?

4. Why do plants need food? Why do animals need food? (Now, do not say, "to keep them alive." Just how does food keep plants and animals alive?)

5. What finally happens to the food in plants and in animals? Why do plants need energy? How do they get it? Why do animals need energy? How do they get it?

6. How do animals get the oxygen that they need? How do plants get the oxygen that they need?

7. Explain the food cycle described on page 329.

IV. Think out the answers to these questions:

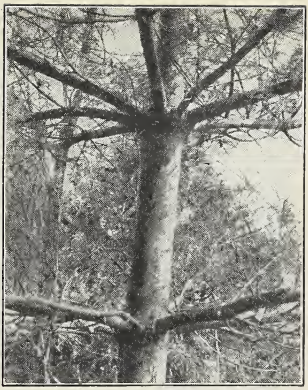
1. Can you think of any plants that do not get minerals or water from the soil or from the water?

2. Do plants digest food?

V. Vocabulary. Did you find any new words?



Hugh Spencer, Chester, Conn.



Hugh Spencer, Chester, Conn.

CHAPTER THIRTY-SIX

TREES

Tell a tree's age. Did you ever tell the age of a tree by counting the rings in the stump? Try it next time you find a stump or the end of a log. The tree grows from a ring just below the inner bark at the outer edge of the wood. [This ring from which the new wood grows is called the *cambium.*] Each year a new ring of wood grows just outside the old wood but inside of the inner bark. If you count the rings of wood, you count the years of growth. Some of the great trees of California have nearly two thousand rings.

In the young pine tree you can also tell the age by the circles of branches as you see above. Each year a new circle of twigs grows out from the buds at the ends of the twigs. As the pine tree grows older, however, you can no longer tell its age by the twigs. The lower branches become shaded and die. They are broken off, and the bark and the wood of the trunk grow out over the broken butts of the branches and conceal them.

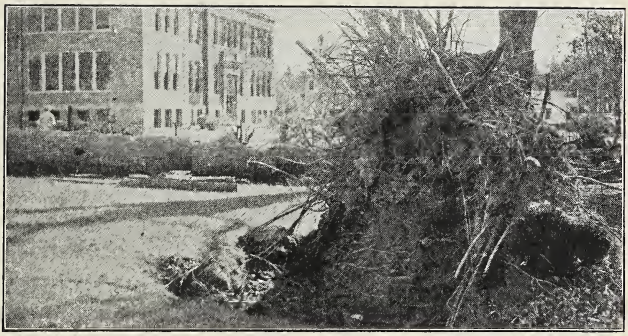


1. A hairy bud, 2. a sticky bud, 3. development of a bud into a twig

What is in a bud? Watch the buds as they open in the spring. The bud has a covering of scales. In some kinds of trees the bud scales are coated on the outside with a varnish, and in other trees the scales are covered with coats of minute hairs. Bees gather the varnish, or gum, from the poplar buds to waterproof their nests. The tree uses the gum to waterproof the buds so that they will not become water-soaked and then freeze. The hairy coating of bud scales helps to shut out rain and bitter winds of winter. The varnish and the hairs help also to keep out insects that would eat their way into the bud to get food and protection from cold and winter birds.

As the bud opens, the bud scales fall away and leave scars which you may see on the twigs. These scars show the location of the buds of previous years. You can easily see how much the twig grew in each of the last few summers. In the "heart" of the bud, inside the coating of bud scales is the "growing point," that grows out to be the new part of the twig. Surrounding this tiny bit of a stem, you can make out the tiny beginnings of leaves. As the bud opens these rudiments (beginnings) of leaves rapidly expand. Watch them in the spring.

As the leaves expand from the bud, the stem lengthens. The expanding leaves must find their



Hugh Spencer, Chester, Conn.

Roots anchor the plant, but here this anchor failed

place in the sun. Therefore, the tree grows ever upward and outward.

Of what use is a stem? Each year the trunk must grow thicker and higher to keep the leaves in the sun where they may do their work of making food for the tree. If you have tried to roll a log out of your way, you know how strong and heavy the great stem of the tree becomes to support masses of leaves and branches. The stem also must produce a passageway for the sap as it goes upward carrying the soil water with dissolved minerals. And the stem, too, must provide a passageway for the sap carrying the food, which the leaves have made, down to the growing stem and to the growing roots, often far in the ground.

The growing roots. As the twig grows upward and outward, the root underground grows too. Each year new root branches spread out in the soil. As the tree grows bigger above ground, the roots must go further to find more soil water with minerals to supply the new leaves that are making more food. Each year, too, the tree needs more widespread

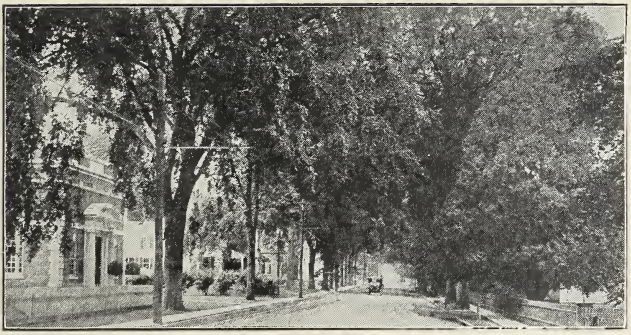
anchorage. In the winter gales and in the summer thunderstorms it takes a mighty root system to hold a big tree. Now and then we see one turned over by the pull of the wind. Only a small portion of the root system is exposed to view, but it gives us some idea of how the roots are interlaced through the soil.

A tree's battle against city life. Who does not enjoy trees? Have you walked along a sun-scorched road or street when the sun felt as if it would broil your back and head? And have you enjoyed the shade on another road? Which is more beautiful, the raw unshaded street of the new town or the tree-bordered avenue? Even in the big cities trees add beauty and comfort.

But the trees have a hard struggle in the city. Cement pavements shut off their water supply, for the rain cannot enter the soil. The soil becomes exhausted of its food-forming minerals, for dead leaves cannot rot away to return the minerals to the soil. Gas leaking from pipes poison roots. Horses gnaw away the bark, automobiles are driven against them, and thoughtless people break off branches and nail signs on the trunks.

Many cities and towns have laws to protect their trees. Some have city foresters or shade-tree commissions. A tree cannot be trimmed except by the order of the authority, for trees are often damaged or their beauty spoiled by poor trimming. A tree may not be removed except by official order. Some towns even require houseowners to plant trees before their houses. Around each tree an unpaved strip or space is left for the rain to soak into the soil.

Choosing a tree to plant. The right kind of tree must be chosen for planting. The rocky hillside, the sandy waste, the gravel left by the steam



Hugh Spencer, Chester, Conn.

A street made attractive by trees

shovel, the rich soil of the river bottom, the swamp land, each has a kind or several kinds of trees that suit it best. Few trees can thrive in the city, but some can. In many vacant city lots you find a native of China, the ailanthus, or tree-of-heaven. Most people do not like it and its planting is prohibited in some places; however, like the English sparrow, the rat, the mouse, and the alley cat, it makes an interesting bit of wild life that can survive in the desert that man has made of the city. Poplar trees usually grow well in the city, and, because they are ornamental, they are popular, but their roots search out water pipes, grow in through the joints, and often stop the pipes with their dense growth. For this reason, their planting is quite generally prohibited.

Among the trees that can live in the city are the plane tree or buttonball, the red oak, and in the northern cities the elm. Many trees have been imported from other lands for our cities. Among them are the oriental plane, or buttonball, and in the southwest the eucalyptus. The cone-bearing trees, like pines



1



2

Steps in planting a tree

and spruces, seldom do well in a smoky industrial city. Perhaps it is because their leaves become coated with fine dust that fills their breathing pores. The deciduous trees, trees that drop their leaves in the autumn, have a new set of leaves each spring, while the leaves of most conifers (cone-bearing trees) last several years before they fall, although new leaves appear each spring.

Planting a tree. We seldom plant the seeds of shade trees in the places where we want the trees to grow. Seeds are planted in nurseries and the young trees are transplanted where we want them. This is safer for the sprouting seedling and gives us a larger tree where we want it, for, at best, trees take a long time to grow.

In transplanting a tree it is necessary to use care, for the tree is a living thing and will die if abused. First select the tree to be transplanted. Sometimes the tree may be growing in the woods, but for transplanting, sturdy and well-shaped trees are usually found in the nurseries. The tree is dug well out from the trunk, loosening the roots as little as possible. A good ball of earth is taken up with the tree. A piece of bagging is slipped under the ball of earth

and tied to protect the roots from breakage and loosening. Most of the root system has been cut in digging the tree, therefore, the branches are trimmed back to equal extent so that the new leaves when they unfold will not give out too much water.



The hole to receive the tree should be a foot bigger all around than the ball of earth about the roots. Some good rich soil is thrown in the hole and the young tree slipped into place. Rich soil is added, stamped firmly against the roots. When the hole is filled, a bucket or two of water is sometimes poured over the roots, although some nurserymen say this retards the delicate new roots.



Steps in planting a tree

The best time to transplant a tree is in the fall after the leaves are shed and the growth has stopped. Winter will do as well if the ground is not frozen, or early spring. The poorest time to transplant is the summer when the leaves are giving off moisture under the warm sun.

Enemies of trees. A tree has many enemies. Caterpillars of the gypsy moth and brown tail moth, emigrants from Europe, have destroyed hundreds of trees in the northeastern part of our country.

Caterpillars of the tussock moth are more widespread. Tent caterpillars build great unsightly nests among the twigs from which they travel out to strip the trees of leaves. Beetles of many kinds bore through the bark and into the inner green bark and even into the wood. Over a hundred thousand kinds of insects attack trees.

We must help the trees against their insect foes. Spraying with poisonous solutions kills many kinds of insects that feed on the leaves. Sometimes bands of fly paper or sticky gum or even bands of folded burlap are used about the trunks to stop the caterpillars that crawl up from the ground. The egg masses of tussock moths may be scraped from the trunk in wintertime and burned.

The best defense against insects is to help their natural enemies, especially the birds. Practically all land birds, including seed-eating birds, feed their young with insects. If we protect the birds, we help the trees. Nesting boxes, feeding stations, birdbaths and drinking places should be provided. Dust baths, too, help the birds, for they dust themselves to kill bird lice. There should be many trees and bushes for the birds to find shelter and nesting sites. Bushes, trees, and vines that produce berries are especially good for the birds. Among them are wild cherry, dogwood, spice bush, highbush cranberry, honeysuckles of many kinds, hawthorn, elderberry, greenbriers, and many others. Two great enemies of birds need to be controlled, cats and air rifles. If cats are well fed before they are let out of the house, they will kill fewer birds. As for the air rifle, shooting bottles is just as much fun as shooting birds.

Besides birds, other small creatures also kill insects. Insects are the chief food of frogs and toads. Many kinds of insects kill other insects. Wasps hunt

caterpillars as food for their young. Ichneumon flies lay their eggs in tunnels of beetle grubs. Spiders spread their webs to catch insects. Lizards, snakes, and wood newts feed upon them. With all the enemies that use insects for food, it is remarkable that they are still a pest. Yet the insects have developed one trick that keeps their numbers ever threatening us. They breed by the millions and millions. If we do not help their enemies, we may suffer from insect attacks on our trees, crops, and our own bodies.

How to Learn about Trees

I. Study about trees by observation.

1. Learn how to tell the age of a tree. Cut across a twig as thick as your little finger or find a log or stump cut straight across. Look for the rings running around the center through the wood. Count the rings in the wood, not the bark. Each ring is a year's growth. How old is your tree or twig?

2. Tell the age of a young pine tree by counting the circles of branches (see page 331).

3. Get some large tree buds like those of the horse chestnut. Take the buds to pieces, scale by scale, and find what makes up a bud. Place some twigs in a tumbler of water and allow to stand for two weeks. Often the buds open and show you what is inside.

4. Examine twigs to find how much they grew during the year (see page 332). You can easily see the markings for several years.

5. Grow some corn seedlings in a dish of sawdust or sand. When they are a foot high, wash away the sawdust to see how the roots have branched and occupied the dish.

6. Examine the trees of your city or village or about your home for evidence of health or damage. Try to determine the cause of the damage and make recommendations for a remedy.

7. Learn of regulations for street trees in your community, if there are any such regulations.

8. Get a book from the library in which the trees and their leaves are pictured and learn the names of the common trees about you. What kinds grow along the city streets? in the parks? in the woods? along the roads?

9. If it is possible, select and plant a young tree where one can be planted to advantage. Study pages 336 and 337 to see how it should be done.

10. Examine the trees for insect enemies. Gather the masses of tussock moth eggs and destroy them.

11. Provide nesting boxes, feeding stations, and baths for birds so that they may be attracted to eat insects.

12. Learn insects that destroy insects. Learn other animals that destroy insects. Look in the library.

II. Read the chapter.

III. Test yourself by answering the questions:

1. How can you tell the age of a tree?
2. What is a bud?
3. Name two ways in which a stem serves a tree.
4. How does the root serve a tree?
5. Name some dangers of city life to a tree and tell what can be done to relieve the tree.
6. Name some of the trees that grow in your vicinity. Can you recognize them?
7. What precautions should you take in transplanting a tree?
8. Name some of the insect foes of trees and tell how the insects may be attacked.

IV. Think out or investigate these questions:

1. Why can you not tell the age of a tree by its size?
2. How can you tell the age of a twig or small branch?
3. What difference do you see in the shapes of trees that grow in the forest and those that grow in the open? Why the difference?
4. Many of the worst insect enemies of trees have come to us from foreign countries. Learn what the United States Government is doing to prevent others from coming.

V. Vocabulary. Have you any words to add to these?

(cambium) rudiments deciduous conifers



Philip D. Gendreau, N. Y.

CHAPTER THIRTY-SEVEN

FORESTS

How forests control water supplies. Did you ever sit down on the ground in the big woods? Damp, wasn't it? Did you dig into the ground a little? On top there was a mass of dead leaves. Lower down the dead leaves had gone all to pieces. In the mass you might have found white threads of mushrooms and other fungi. Worms and grubs perhaps were working their way through. All these living things were feeding on the mass of dead leaves and making it gradually into mineral substances again. This decaying mass of material is called *humus*. Below the humus, if you continued to dig, you came to mineral soil or to bare rock.

When the rains fall or the snow melts, the dead leaves and the humus act like a great sponge which takes up and holds water. Then during the dry season water gradually oozes out again. The forest thus helps to reduce the rush of water that makes floods, and helps to supply water in the dry season to keep

the streams flowing. In addition to supplying lumber, wood pulp, and other products, the forest governs our water supply, as necessary to us as air and soil.

What we do with wood. Do you know how many telephone and telegraph and electric light poles there are in the United States? Practically all of them were tree trunks. Five million new poles are needed each year. A hundred million new railroad ties are needed each year. Then most of the houses in the United States are built entirely of wood, and floors, doors, window frames, and many other parts of stone or brick houses are of wood. Most furniture is made of wood. Count up the things that you meet in a day that are made of wood.

Then there are many other products that come from trees. Almost all paper is from wood. Many articles, such as combs, fountain pens, and penholders, are cellulose products. *Cellulose* is the substance that makes up the cell walls of plants. Most of our supply comes from wood. Rayon, once called *artificial silk*, is a cellulose product made mostly from wood. In addition there are many other products that come from trees: turpentine, varnish, oils, rubber, coffee, nuts, maple sugar.

Saving the forests and using them. It takes over fifteen acres of trees to provide paper for an edition of a Sunday newspaper. Yet paper takes only four per cent of the wood that is cut. How long will our forests last? Our supply of building lumber now comes chiefly from two places, the pine belt of the Southern States and the far Northwest. Paying freight on lumber from Oregon to New York makes lumber dear. The forests of Oregon are being rapidly destroyed. Then what?

The United States Government still owns great stretches of forest which it is preserving as forest.



Ewing Galloway N. Y.

Wasteful lumbering leaves a barren land

Trees are cut in the National Forest and marketed, but the forest is preserved. On private lands, the forests are usually destroyed when the lumber is taken. This destruction of the forest is not necessary, but private growers are usually anxious to get all the money they can in a hurry. Therefore, a very large part of the forest is wasted without providing any return, and without thought for the future. Water companies who own great stretches of country are more careful. The important thing to them is the water rather than the lumber. When they take out the lumber they preserve the forest.

Forestry and forest protection. The forester always thinks of the future forest. He watches the young trees and the seed as well as the trees that are ready for cutting. He takes out worthless trees that shade young good trees and occupy ground that would support valuable trees. To the forester these are weed trees that crowd out the forest crop. He does not let them destroy or hinder his young crop. When the forester marks trees for his lumber crop,



Seed trees left standing in scientific lumbering, and their children

he allows some good trees to stand to supply seed for replacing those that are taken.

When land without good trees is to be developed into forest, seed or young trees are planted. Usually the seed is planted in forest nurseries and the young trees transplanted out where the forest is to grow. As the young trees grow, they become crowded and some must be taken out, or none can grow properly. Thinning the forest in this way is as necessary as thinning out your garden when it is overcrowded.

The fire demon. The greatest enemy of the forest is fire. Many fires are started by farmers burning brush, and many by campers who do not make sure that their campfires are out before they leave. Many more are due to smokers who toss aside lighted cigarettes or burning matches. Many fires are started along roads when lighted cigarettes are tossed out of car windows. Even if all carelessness could be stopped, there is still lightning to start fires. Two forest rangers reported that they had been fighting fires all summer that had been started by lightning. They knew lightning to be the cause, for they were far back from the lakes where campers or fishermen never traveled.

The forest on the farm. A farmer likes to have a woodlot on his farm. It supplies him with firewood, fence posts, and formerly with fence rails, although now he often buys wire fence. In addition, on a well-managed woodlot the farmer can take out trees to sell for poles.

The woodlot must be cared for if it is to do its best for the farmer. If it is used to pasture cattle and allowed to grow up to useless trees and bushes, it may yield him little. If the worthless trees are cut out and the bushes reduced to the point where they will not crowd out the young trees, the woodlot will yield a good return for the care it gets.

Forests for the people. Many cities own forests either to protect their water supplies or to furnish recreation for the people. Both are necessary. State and national governments similarly provide for the people water, recreation, and forest products. Unfortunately private owners have suffered so much from careless and destructive persons that many forests and woodlands now are closed to the people. This is most unfortunate, but the landowners are not to be blamed.

Too often strangers have entered a woodland, dug plants, broken bushes and trees, littered the pleasant spots with garbage, tin cans, picnic trash, and often set fire to the woods. Little wonder that landowners have posted the land against trespass. When you go on the land of another, do it no injury. Do not break or dig plants, either small plants, trees, or bushes. Do not leave picnic litter.



U. S. Forestry Service

A fire lookout



Ewing Galloway, N. Y.

The forest offers healthful recreation

Bury your old tin cans and paper. Leave the place a spot of beauty that you and others may enjoy.

In Chapter Forty-three you will learn more about the care of the forest.

Things to Do in Learning about Forests

I. Read the chapter.

II. Study the forest by observation.

1. Gather some humus from the woods. Record in your notebook what you find as you dig. Take some from the top, some from just below the surface, and other samples from various depths until you come to the mineral soil. Put your specimens into paper bags, each with a note as to depth at which it was taken and anything that you found there. Bring them to school or to your home and examine each specimen carefully with the lens. Tell how the character of the dead stuff varies as you go downward.

2. Saturate some of the humus you brought. Let it drain for a little. Then weigh it carefully. Dry the humus slowly with heat until it is thoroughly dry. This may take some hours. When thoroughly dry, weigh again. What part of the wet humus was water? Does this help to account for the water-holding power of the woods?

3. List as many uses of wood as you can think of. Keep a list of all the uses that you see in the course of a day.

4. List all the products that you can think of that come from wood or from the forest. Look up further products in the library.

5. In your notebook paste pictures illustrating what you have learned in this chapter.

6. Make up posters on the care of the woods near your home.

III. Test yourself by answering these questions:

1. Write in a list of all the values of the forest.

2. Write a list of forest products in addition to lumber.

3. Where does most of the lumber of the United States today come from?

4. How can forests be produced again on land that has been "lumbered off"? Planting new trees is very expensive. How can the forest be cut so that planting will not be necessary?

5. What starts forest fires and how can they be prevented?

6. How do National and State Forests benefit the people?

IV. Think out or investigate the following questions:

1. How is wood wasted? How may the waste be stopped?

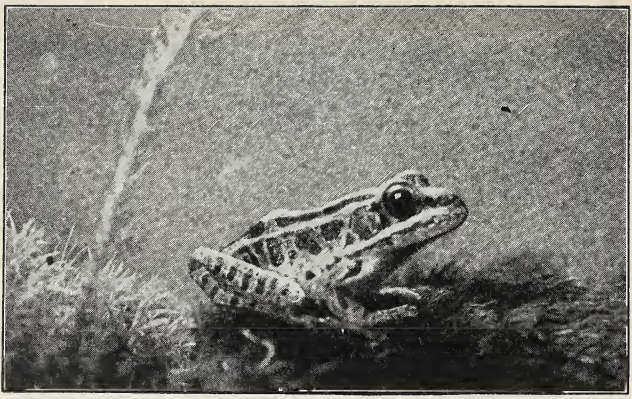
2. For what uses might wood be replaced by other substances? For what uses can nothing be substituted for wood?

3. What destroys wood besides men and fire? How can the destruction be controlled?

4. Locate the National and State forests. Does your State have State forests? For what purposes are they used?

V. Vocabulary. Watch the spelling. Here are a few suggestions of scientific and common words:

humus cellulose rayon trespass



Hugh Spencer, Chester, Conn.

CHAPTER THIRTY-EIGHT

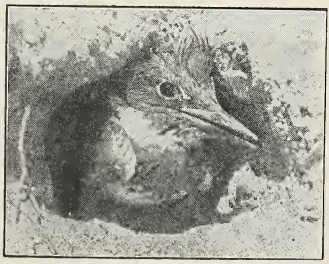
SPRINGTIME IN THE BROOKS AND PONDS

You probably like to dabble in the brooks; so do scientists. A whole world of interesting things live there. They live a strange life—that is, strange to us—though it need not be strange if we study it. Probably the farmer and the city man who has a country estate knows less about the life in the brook that flows through his fields than he does about the life of China or South Africa. He has never seen it. Even the average fisherman who wades the stream and casts his line in the likely pools does not take time to study the swarming life in his favorite streams. The chief equipment that you need to study this life is patience, although a homemade net, a few bottles, and a magnifying glass will help in the study.

Still-hunters. As you approach a stream or pond, you often hear a "plump," as a frog dives into a pool. He had been sitting still upon the bank. He may sit still there for hours, but he is not idling away the time. He is still-hunting. On a still-hunt, the hunter sits still until the game comes along. The

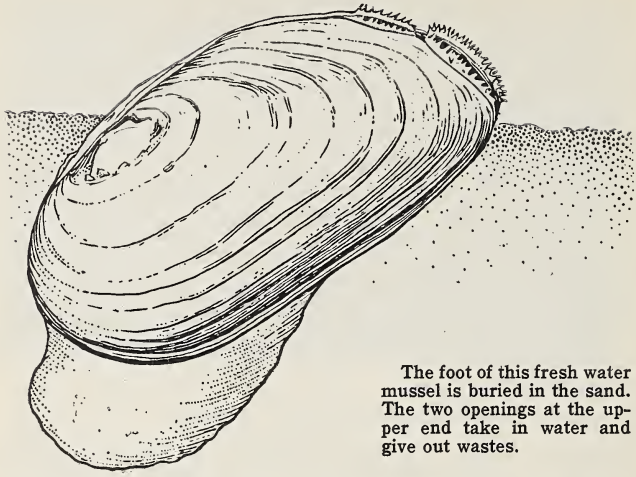
frog's game is flies, moths, or anything else that flits by close enough to his nose to be hit by the lightning flip of his tongue. He will also snap up worms, tiny fishes, or anything else that moves past. Big frogs will eat tadpoles and little frogs. In the aquarium, after the frogs have become accustomed to their surroundings, they will snap up a piece of meat that is dangled in front of them on a wire. When the frog plumps into the pool, stand still and watch. He kicks up a cloud of mud, like the smoke screen of a battleship, and hides behind it. When the cloud of mud floats away, you will probably see the frog resting quietly on the bottom. He can rest there a long time, probably longer than you care to wait. You might think he would get out of breath if you waited long enough and then would come to the surface. But he does not get out of breath in the bottom of the cool brook, for he breathes through his skin as a fish breathes through its gills.

Fishes in the brooks. But let us return to the brook. You probably think first of fishes when you think of the things that live in the water. Usually you can find them. Even in the small brooks you find the small minnows. Shiners, or silversides, and black dace, with a dark line along each side, are common. There are other kinds. Sunfish are little fighters when the small boy gets them on the hook. Sticklebacks, catfish (some varieties of which are known as *horn pouts* or *bullheads*), and suckers are common also in ponds



William Thompson, Mount Vernon, N. Y.

The kingfisher lives in a hole in the bank and eats fish



The foot of this fresh water mussel is buried in the sand. The two openings at the upper end take in water and give out wastes.

and streams. In spring and early summer you may find the nests of fishes in riffles, or little rapids. Usually the male fish hollows out a flat space a few inches to a foot across. He moves out the larger stones with his mouth or by butting his head against them. Smaller stones and grains of sand he fans out with his fins. When the eggs are laid, they drop down in between the little stones on the bottom. Then the mother fish leaves and goes off on her social life, while the male stays at home and guards the eggs. There are many things to eat the eggs. Other fish eat them. Crayfish and salamanders eat them. Insects eat them. The male attacks intruders much larger than himself in defending the nest. Sometimes, however, when the young fish hatch, the father forgets and eats his own children.

Reptiles. As you approach a muddy stream or pond, often a turtle that has been sunning himself on a log slides quietly into the water. Then you will probably not see him again. Sluggish creatures can

stay under water for a long time, holding their breath, then come quietly to the surface and stick their nostrils above the water for a new supply of air. Turtles in egg-laying season just reverse the habits of the frogs and toads. For the frogs and toads must go to the water to lay their eggs. Even the hoptoad of the garden becomes a water animal at spawning (egg-laying) time. Turtles, on the other hand, go ashore to lay their eggs. They dig holes in the sand with their back feet, back into the holes as they dig, and lay their eggs. Then they cover the holes and leave the eggs to hatch. The young turtles, when they hatch, dig their way out and make for the pond. They take care of themselves—if they can. If they cannot take care of themselves or have bad luck—well, there are more of them. Turtles, like frogs, eat almost anything that moves and they will also take dead things. A large turtle will take a big duck. In places where there are many turtles, young ducks must be kept away from the ponds.

Coats of armor. You will find some very leisurely creatures in the water. About the only thing that you will see moving with more deliberation than snail is a mussel. The mussel is even more cumbersome than a snail, but it does manage to move around a little and to dig in the mud. Its digging organ and organ for moving around is called a *foot.* It is just a slab of muscle that the mussel sticks out from between its shells. Somehow it manages to push itself around in the water with the foot. Of course it does not stand on its foot. The water helps to hold it somewhat upright. If you have gone swimming in a creek or pond, you probably have noticed that you can pick up a stone three times as big as your head while the stone is



Young fish with yolk sac which contains food



Hugh Spencer, Chester, Conn.

This spotted turtle is a water dweller

under water, but you cannot take it out of water without straining yourself. Water does most of the holding up; it helps buoy up the stone. So it is with the mussel. Water does most of the holding up, and the foot is used to produce the mussel's awkward motion.

With its coat of armor, you might think a mussel would have few enemies that could harm it, but it has many. Leeches (also sometimes called *blood suckers*) feed upon them. Many kinds of fishes and turtles eat them. Even muskrats eat them. Sometimes their worst enemy is man. Along some rivers are large piles of mussel shells left by the ancient Indians. Along the Mississippi and some of its larger tributaries,



This water insect has legs like oars, and floats on his back

mussels are fished in larger numbers to make pearl buttons, for the inside of their shells is pearl. The mussels feed on anything small enough to be carried by a current of water into the little tube that can be stuck out between the shells at the end opposite the foot. This little tube, called the *siphon*, is double, water going in one opening and coming out the other.



Fresh-water snail

Snails are everywhere in the water. They crawl on the bottom, over the rocks and up plant stems. You can even see them crawling upside down on the under surface of the top of the water. They eat the scummy microscopic plants that are on everything under the water. If you have kept snails in your aquarium, you know that they clean off the green scum that collects on the inside of the glass. This green scum is made up of microscopic plants. If you have a microscope at school, you can easily examine some of these plants. The snail has a tongue like a file. It is set with little teeth and hooks with which the green scum is raked off. Snails have as many enemies as mussels, and just about the same enemies, including man, for some kind of snails are served as a table delicacy.



Crayfish



Water strider



Whirligig beetle

You will find *crawfish*, as the boys call them, or *crayfish*, as the books call them, in most streams. In early spring they come up from hibernation in the mud and sand. Then they crawl around the bottom,

hiding under stones or lying still until something moves near. It may be a small fish, a tadpole, a water insect, or a worm. A quick snap of the pincers catches the animal. Then very deliberately the crayfish tears the victim to pieces with its pair of pincers and eats the bits. If it can find nothing alive, dead stuff will do for food. Plants will do if there is no meat. In the aquarium, they will eat bits of meat, and they will also eat each other. If you put a big one in the aquarium with little ones, there will shortly be only the big one there.

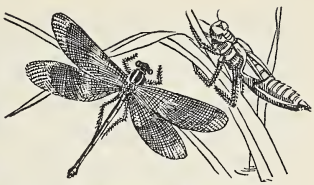
You sometimes catch a crayfish with round eggs attached to the under side of the rear half of the body, its tail part. The eggs are glued fast and carried until they hatch. Then the young crayfish hold on by their pincers and ride around on their mother for a week or so. Finally they let go and set out in the world for themselves. It is a rough world. They are eaten by water insects, fish, frogs, and turtles, herons, kingfishers, raccoons, and almost anything else that has a hunger around the water.

Tiny water dwellers. There are hosts of little creatures in the water. If you look under the stones you will find some of them. If you drag a net over the bottom you will find more. If you take some lily pads and other water plants and place them in a dish, you will find still more. Some of them are so small that you need a microscope to see them. Some can be seen easily with a magnifier, and some you can examine with the naked eye. If you gather the stuff from the bottom of the pond, take it home or to school in a can or jar, and watch it, you may be surprised how many different kinds of living things are present.

On the underside of stones, you will find many animals. Some of them are just tiny pieces of flesh longer than broad. They move along slowly as a



Caddis fly, larva, and movable house



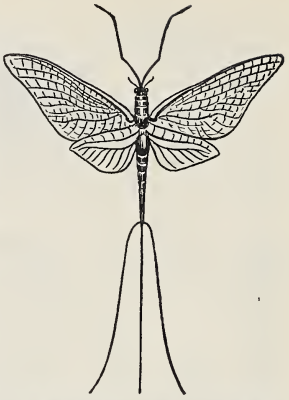
Dragonfly and nymph

snail. They are tiny flatworms. There are several different kinds of flatworms in the brooks. Most of them eat other animals, dead or alive. You can keep them in an aquarium by feeding them a tiny bit of juicy meat from which they suck the juice. The mouth is on the underside of the body about halfway back. If a flatworm loses its tail end, it grows another tail. If it loses its head, it grows another. If it is cut in half, each half grows another half to replace the missing halves. It is small wonder that they are very common in the water. Few people, however, see them. They are small and they hide from the light.

If you take home some of the bottom stuff you will find many other small worms. Some of them live in little tubes in the mud. Others swim actively about. Some kinds keep lashing around. Worms are very common in the water and most kinds are very small.

Under the rocks you will find some interesting little fishermen. If you look closely you will find their tiny nets spread facing upstream. At the point of the net you will find the little house door of the fisherman. He builds his house of tiny grains of sand cemented together by a kind of silk. He weaves his nets also of the same kind of silk. Any small animal caught in his silken net is food for the fisherman. If you carefully open the house, you will find the fisherman is a little wormlike creature with legs at the head end. If you try to pull him out of his

house you will tear him apart. At the tail end he has two little hooks by which he holds on to his house. He holds so well that you tear off his tail end before he lets go. Relatives of this little creature are also found crawling over the bottom on the dead plant stuff. Some of them make their houses of bits of sticks and other dead plant stuff. When they want to move to a new neighborhood, they move their houses along with them, simply dragging themselves inside their stick houses. They are called *caddis worms*. They are not really worms, but the young, or larvae, of the caddis flies. They may live for a year or for two years under water. Then they come to the surface, change into flies, and fly away.

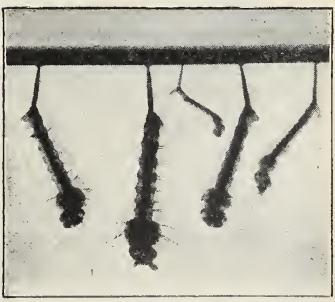


The May fly keeps his long tails after he grows up

Young insects. Many other kinds of insects and young insects are living at the bottom of the streams and ponds. Young dragonflies crawl around catching and eating any little animal small enough to be caught and eaten. They will catch other insects, little worms, small tadpoles, and small fish. You will find, clinging fast to the undersides of the rocks, little insects with two or three "tails." They are stone flies and May flies. After a year or two under water they come to the surface and fly away. You may also find tiny, dark, wormlike creatures sticking to the upper side of rocks and pebbles where the water is so swift that it would seem no little creature could stick. They are the young of midges and blackflies. If you have visited the north woods or the mountain woods

in the early part of summer, you perhaps have met the adults of these little creatures. If you have met them, you have not enjoyed them. Some kinds of midges go right through mosquito netting and make your life miserable. They feel like red pepper. Blackflies are slower to make themselves known. In fact, you may not notice them; but an hour or two later, you may find annoying lumps over the back of your neck and face. If you have had any experience with blackflies, you know that you are usually not worried by them far from the water. They lay their eggs in the water and grow up there.

Perhaps you have had unpleasant experiences with other water dwellers. As you approach a quiet pool, you may see some tiny wiggling things drop down by jerky movements to the bottom of the pool. If you stand perfectly still, they will come wriggling up again. Then you may see some of them hang by their tail end at the surface of the water. They are young mosquitoes coming up to breathe. They breathe through the tail end of their bodies. They may breathe for a time under water, but such active little creatures seem to run out of breath when breathing only water like fish. Then they come up and breathe air. If you collect some in a bottle, you can take them home and watch them grow. Tie a piece of mosquito net over the bottle and keep them until you see mosquitoes in the bottle.



Hugh Spencer, Chester, Conn.
Mosquito larvae (wrigglers)

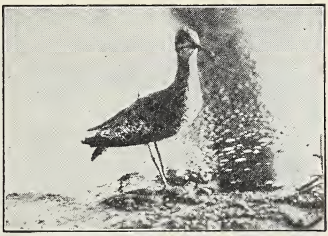
Shore hunters. You may find other and larger animals living along ponds and streams. If

you tramp along, a heron may rise and move on up the creek to alight again. If you go cautiously, you can easily creep up where you can watch the heron fishing, but you must be patient. A heron will stand like a statue for more minutes than you care to sit like the bump on a log. Then you may see it take a slow step and jab down its long bill. It may raise its head with a frog or small fish, or a crayfish. Often, however, it seems to miss and come up empty-billed. Usually you see only one heron at a time, although occasionally there may be a little group of them during the migration period. Apparently the average stream furnishes only enough food to support one heron every few miles.

You often see little sandpipers bowing and tilting along the shores just at the water's edge. They are looking for anything moving—insect, fish, worm, or small crayfish. You may see only a lone sandpiper or you may see a little group of them. They are not much afraid of you, but they keep a few yards ahead running along the water's edge, occasionally stopping for a moment to look down and jab their bills quickly at likely morsels.

Another group of birds are the ducks. They are not so plentiful as they formerly were, but on the larger or more hidden streams you will find them in the migration season. They feed upon the seeds and the roots that grow in the muddy bottom. There seems to be plenty of food in marshy creeks and ponds. The reason for their falling numbers is their enemies. In the ancient days of America they had many enemies, but were able to outwit many and breed fast enough to overbalance their losses. Before the white man came, the flights of ducks were important factors in keeping the Indians from starvation. Now times have changed. Gunners with modern guns are surely

reducing their numbers. A time is coming when ducks will be rare. Already many species (kinds) of ducks have become very rare or have disappeared entirely from large sections of the country. Shall we save the others?



William Thompson, Mount Vernon, N. Y.

The busy sandpiper

Water as a home. Water is a good place to live, if the creature is adapted (fitted) to live there. You read in an early chapter of the adaptation of water creatures that enable them to live in water. They must be specially adapted to live in water, for there are certain disadvantages to living there, and the water dwellers must overcome these disadvantages. It is hard to breathe in water because there is not so much oxygen in water as in air. The oxygen that the water dwellers find in the water is dissolved. If the water gets warm, it cannot hold as much dissolved air or oxygen as when it is cold. Therefore shallow ponds, which may become very warm in summer, are not as good dwelling places as deeper lakes which do not heat up all the way to the bottom. Sometimes, in hot weather, fishes in shallow ponds come to the surface and gasp for breath. There are disadvantages, however, in living in the great depths. Sunlight does not go very deep into the water. You know that green plants cannot grow without any light. You know, also, that all food comes in the end from green plants. If plants do not grow in the deep water, the food must come from outside the depths. In the deep parts of the lakes bacteria may grow. They do not need light. They grow on dead stuff and cause the decay of the dead things. Foul and poisonous gases

may arise from decayed animals, as you know if you have gone near them. These poisonous gases may poison the water so that fishes and other water animals cannot live.

A disadvantage of living in small waters is that they may dry up in summer droughts. Then water dwellers must die unless they can travel overland or defend themselves against the drought. Frogs travel overland, especially on wet nights. If the pond dries too much, they may leave at night and find another. Eels also travel overland in wet grass. The leaves of many water plants just shrivel up, but their roots and under-mud stems may stay alive until the rains come again.

The green scum that you see on pools in the summer is made up of delicate green plants that can resist drying, and freezing, too. The green part dries up, but the plant forms little microscopic bodies tinier than seeds. These little bodies, called *spores*, have tough walls that do not allow the plants to dry out completely. They just sleep until the rains come, and then they grow out once more as green scum. Perhaps you have noticed how quickly the green scum comes back to a pool after a drought or a freeze. The formation of spores is an adaptation to life in waters that dry up and freeze.

How to Study about Springtime in the Brooks and Ponds

I. The best place to study the life of the brook and pond is at the brook and pond. If you cannot reach such places at once, make the best of pictures and books at the library. Nature magazines also are especially valuable in supplying pictures and observations of others. It is more fun to study the life where it lives. Some of the living things, however, can be better



Hugh Spencer, Chester, Conn.

One type of algae magnified 125 times

studied close at hand in the laboratory, whether your laboratory is your classroom or your backyard. Get some bottles with wide mouths and corks. Make yourself a net on the end of a stick with a loop of wire and some mosquito netting. Go out and drag the bottom of the ponds. Hold the net on the downstream side of a rock and raise the rock. Many living things will be carried by the current into the net. Put them in your bottles and take them home. Use a number of jars as aquaria to put your catch in, with some living plants. Do not put many in each jar. You can probably find books in the library that will help you learn the names of the animals and plants that you have collected.

As you study the animals in the brooks and ponds (or in pictures), notice the following: What sort of place do they inhabit, the underside of rocks, the mud, water plants, running streams, or ponds? Are they attached or free-swimming? How do they escape their enemies? What seem to be their enemies? What seems to be their food and how do they obtain it? What kinds of animals and plants live together? How do they benefit by living together?

II. Read the chapter.

III. Test yourself with these questions:

1. What animals with backbones can you find living in the fresh water?

2. What animals without backbones can you find? Write down a list.

3. What animals do you find that live both under the water and out of water?

4. What kinds of animals visit the brooks and ponds to hunt for food?

5. Where does all the food that supports the many living things in the fresh water come from?

6. What ways of escaping their enemies do you find among water dwellers?

7. What animals are primarily hunters, feeding upon other animals?

8. What animals are primarily plant-eaters?

9. What animals spend their young lives in the water, but leave to spend their adult lives elsewhere?

10. What plants in the water take the place of grass in the fields?

11. What advantages and what disadvantages has fresh water as a dwelling place for plants and animals?

IV. Think out or investigate these questions:

1. What effect on the lives of other fresh-water creatures would result if all insects were killed?

2. Bass feed upon smaller fish, frogs, and almost any other creature that swims or runs. What changes in the life of a pond might result from the introduction of bass?

3. Do the inhabitants of fresh water have any effects upon man?

4. How has man changed the life in the fresh water?

V. Vocabulary. Have you any new words?

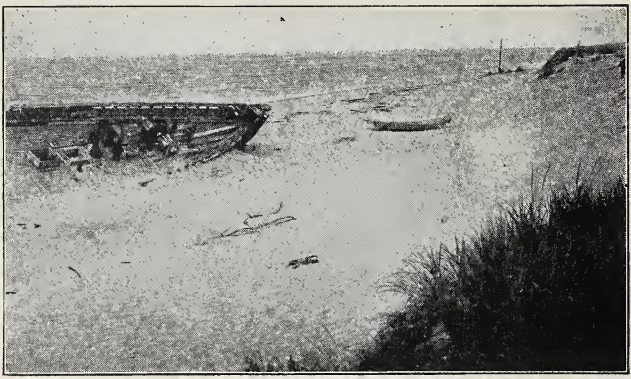


Ewing Galloway, N. Y.

CHAPTER THIRTY-NINE

WHEN SPRING TAKES YOU TO THE SEASHORE

If you live within reach of the seashore, you will hear the call of the waves and the wind in the springtime. Dad probably hears it too. With only a little persuasion you may get a day at the shore before the crowd goes there. Or you may be fortunate enough to know some spots where the crowd does not go. They are the best places to study the living things of the salt-water shores, but even where the crowd goes, life may go on below the water line little affected by the rushing around of summer visitors. You must know how to see the salt-water life. You need old clothes, a small spade, and perhaps a stout knife to pry things from the rocks. If you want to bring some things back alive, take along some jars or buckets, but salt-water things will not live long away from the salt water. You can make some valuable additions, however, to the school museum and you can carry back some valuable things to show your class.



Underwood-Stratton, N.Y.

A sandy shore

Things living above the beach. If you are fortunate enough to visit a shore where the "improvements" have not driven away the wild things, you will find things that you have not seen inland, and you may see some of the same animals and plants. You may find some animals, including birds, in both rocky and sandy environment, but you will find others that prefer one or the other kind of shore.

You may find, if you are lucky, a migration of swallows, for unlike most birds they migrate boldly by day. They are strong, swift, and agile fliers with little to fear. Few beasts or birds of prey can touch them. It is a sight worth a long journey. Birds fill the air as far as you can see, flying northward low and high in the air. They fly close to you, swooping and diving, but going steadily forward.

They feed as they fly, snapping up any little insect that is on the wing. All the common swallows are flying northward together. Many birds in migration follow the coast in this way, perhaps because it is a pathway easily followed.



Publishers Photo Service, N. Y.

A rocky shore

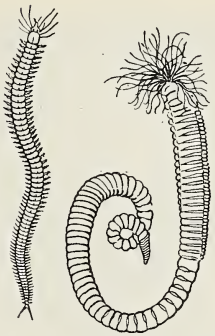
You will see other birds on the beach or on the rocks along the water's edge. Gulls are sure to be there. A group of them may be resting on the sandy beach or on the rocks or perched on the ridge of a fish house patiently waiting for the next clearing out of fish refuse. They have learned to get along with men, and men do not molest them, for they help keep things clean. Dead fish or other animals washed up on the beach are soon found and eaten. Gulls are nature's beach cleaners. In some States this service is so highly valued that there is a heavy fine for killing a gull. Gulls will take live food also. Perhaps you have seen a gull take a live clam from the shallow water, fly up in the air, and drop it on the rocks or hard sand to break it open. Then the gull alights and eats the helpless clam. Gulls will also take the young of other sea birds from their nesting places on the rocks. Gulls will eat almost anything that they can tear apart with their strong bills. They are well adapted to life on the shore.

You will see the charming little bands of sandpipers running up the beach. They follow each retreating wave, now and then driving their sharp, long bills into the sand. As the next wave comes in they run up the beach, only to follow it down again searching and driving the bills into the wet sand. If you risk wet feet you may see what they may find in the retreating wave. You will see some tiny little creatures swimming vigorously around in the half inch of water and burrowing into the sand as the water drains away. You can dig up some of these little sand-colored creatures with your fingers, if you are quick. They belong to the group of animals called *crustaceans*. The big fellows of the group are crabs and lobsters. There are crustaceans of many fantastic shapes in the sea and fresh waters. They run down in size to tiny microscopic fellows that swim about on the surface of the deep sea and in fresh-water ponds.

If you visit a shore that is lined with sand dunes, you will have a chance to see how many creatures fit into this sandy, barren region, wet sometimes with rain and sometimes with salt spray. You will find many creatures that are the color of the gray and white sand, like the big grasshoppers that you seldom see until they fly away with a great snapping of wings and brilliant display of color. But when they alight, they fold up their brilliant wings and blend with the sand.

Down on the beach where the piles of drying seaweed are lying, you will find more creatures. Kick into a pile of dead seaweed, and a vast host of little things will jump out. Most of them are "beach fleas," not insects, but little crustaceans. You will find little burrows with tracks leading into them and, if you are careful, you will probably see the little ghost crabs, gray as the beach, dance swiftly along

on their toes and into the burrow. You must be quick and crafty to catch one for the school museum.



Sand worm and Tube worm

Attached for life. Below the water line the real sea life begins. The upper part of this water line is laid bare twice a day when the tide goes out. Then you can wade in and find things. Dig carefully with your spade, and you may find a great wealth of living things. You will find less in the sand than in the mud. The beating of the waves on a sandy shore is too rough treatment for most animals and plants. Even seaweed cannot stand it. If you dig, you may find surf clams, some worms, and crustaceans, but most of the great multitude of sea creatures are farther out where the waves do not pound the sand or in the quieter muddy shores in the bays.

If, however, there is something solid to grow upon, like wharf piles or rocks, there is a great population of animals that just hang fast for their lives and live there. Living must be good, for such places are crowded with attached animals. Most of these animals spend the rest of their lives right at that spot. Some, like the mussels and barnacles, swim about when they are tiny, young animals, but when they start to grow up, they settle for life. The barnacles are crustaceans, but you might think they were cousins of the clams instead of the crabs. If you watch them, however, in the little pools in the rock when the tide is low, you can see them thrust

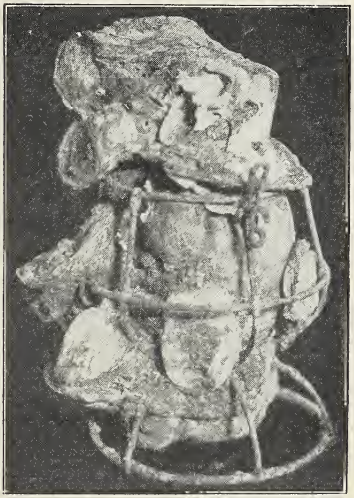
out their feathery feet and feel around for something to eat. Food must come near enough to grab; they cannot go in search of it (see figure on page 41).

Other attached creatures are the mussels. They may grow in such dense clusters, attached to one another by little bundles of threads, that the whole mass sometimes falls off and floats away. Mussels are good food for man and for many other creatures. Mussels belong to the hard shellfish, with oysters and clams. These hard shellfish are called *mollusks*. That is a very convenient name to remember, because there are many different kinds of mollusks in the sea and a goodly number in fresh water and on land. Snails are mollusks and you may see them in great numbers on the rocks. If there is a dead animal lying below the water on a muddy shore, it is often found covered with snails that have flocked to the feast. Still other mollusks are the clams that seek safety by burrowing in the mud, and scallops that can swim, after a fashion.

Oysters live attached to solid rock, to dead oyster shells, or to anything else that will furnish attachment above the moving mud and sand. Oysters have enemies that can feed upon them in spite of their coats of armor. Starfish wrap around them and pull them open. The oyster drill, a little snail, drills a hole through the shell. Boring sponges secrete enzymes that dissolve fine holes in the shells. And man rakes up tons of oysters each year.

Other salt-water creatures. There are many other interesting living creatures in the salt water. Crabs crawl about the sands and the mud. Crabs burrow in the mud above and below the water. Crabs swim, and crabs hide among the rocks. Big crabs catch little crabs, lobsters catch big crabs. Many kinds of crabs catch living animals or feed on

dead things. Many kinds of worms live hidden in burrows in the mud and sand or among the seaweeds. Some of these are permanent residents in their burrows, coming to the mouths of the burrows and spreading out long threadlike appendages which serve as feelers and hands to seize food and others which serve as gills for breathing. When danger threatens, for example when a shadow comes, the worm pulls in its feelers and retreats inside the burrow, for that may be the shadow of a hungry fish.



Ewing Galloway, N. Y.

These oysters attached themselves to an old marine lantern

A great variety of fishes live in the salt water. The sea is the real home of the fishes. There are big fishes and extremely tiny fishes. There are fishes of weird shapes and fishes of graceful and speedy form. There are fishes that have all the beautiful colors of the brilliant flower garden, and, too, there are others drab and dull. Fishes live in the great depths where it is cold and dark. Others live near the top where the sun shines through the water. Some grub along the sandy bottoms, digging out clams from the soft sand. Some live only on other fish, and some eat anything, alive or dead. Many other animals eat fish. Among those that eat large quantities are seals, bears, sea birds, and men.

The plants of the salt water. In the end all things must depend upon the plants. Big fish eat smaller fish, and they, in turn, eat smaller fishes still. Perhaps the tiny fish eat crustaceans. Larger crustaceans may eat smaller animals, but if we follow the food line far enough, we come to the plants that make the food in the sea as on the land. The plants of the sea are seaweeds. There are big seaweeds, a hundred or two hundred feet long, the smaller ones you find growing densely on rocks and pilings, and multitudes that can be seen only with a microscope. The microscopic ones have microscopic animals to eat them. These tiny animals are eaten by others a little larger and so the story goes until large fish are taken from the sea to serve as food for polar bear and for man.

Just as we found in our study of land animals and plants the food chemicals are returned again to the soil, so we find in the sea that the chemical elements obtained from the sea return again to its waters. The wastes of animals and their dead bodies are food for other things. Crustaceans take the place of insects on the land. Worms live in both places. Mollusks have their part in destroying the dead or the living and helping to return the minerals to the sea water. Just as on the land, there are bacteria doing the work of undoing the work of plants, turning bodies and the wastes again to the chemical substances which mingle with the waters of the sea.

To Learn about Life at the Seashore

I. Read the chapter.

II. The following study may be made on visits to the seashore or, if that is impossible, from the accounts of other observers. Pictures, museum studies, preserved specimens, and visits to the zoo all help in the study.

1. Make a study of the birds of the seashore. How do they get food? Where do they nest? How are they adapted to escape enemies? What are their enemies? How are the young in the nest protected?

2. Contrast the life on a sandy shore with that on a rocky shore. What differences and what similarities of plants and animals are found?

3. List the animals that are found between the tide levels. What are the chief disadvantages of life in this zone? What are the chief advantages? How are the animals of the zone adapted to life there?

4. What are some visitors to the tidal zone? Why do they visit the zone? Why does man visit the zone?

5. What is the chief disadvantage of life in the sandy shore between the tide levels? Why is there less life there than on the rocky shore between the tides?

6. What are the advantages of living in the mud? What animals are adapted to live in the mud? How?

7. Make a study of the fishes of the sea. How is a fish adapted to breathe? to go through the water? to get food? to escape enemies? What are the chief enemies? What is the chief supply of food? How are the young provided for?

III. Test yourself by running over the questions of the study guide (No. II) and explaining each as you would explain to the class.

IV. Think out or investigate:

1. How does man enter into the cycle of life in the sea?

2. What conservation measures have been taken to preserve the seabirds?

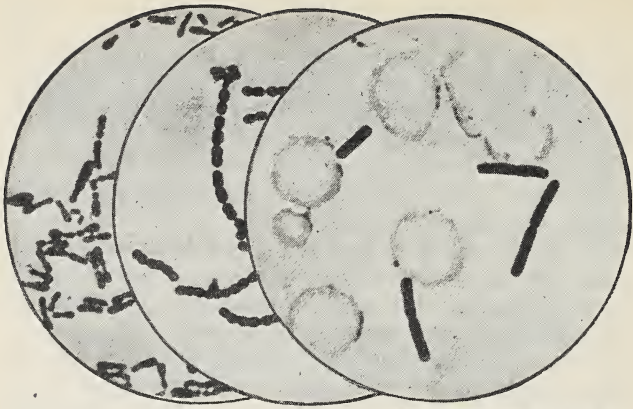
3. What measures have been taken to preserve shellfish from extermination?

4. Are measures necessary to preserve the fish life in the sea? Often there are years of poor fishing. Can you suggest any reason other than overfishing for these poor years?

5. What zones yield man's largest supply of products?

6. What other uses has the sea to man besides supplying products? Which zones are most useful for these purposes?

V. Vocabulary. Have you any new words?



William Thompson, Mount Vernon, N. Y.

CHAPTER FORTY

ARRANGING THINGS IN ORDER

How the animals get their names. Could you name all the animals in the world? Scientists cannot. New animals are discovered each year. A new animal has no name. A scientist gives it a name and describes it in a scientific publication. Most animals discovered nowadays are very small animals. They are chiefly insects and microscopic animals.



There are a good many kinds of animals in the world. Close to a million kinds are known.



How animals are put in order. A million kinds of animals mixed together would make quite a confusion. The scientist tries to straighten out confusion and arrange things in order. In arranging things, he puts them in groups. Suppose the scientist—or you as a student of science—were to go into a storeroom of a museum where had been placed



the following collection of animals, all mixed. Cows, cats, codfish, mackerel, mice, moles, sharks, eels, bees, doves, hawks, crabs, starfish, earthworms, bears, deer, lobsters, flatworms, oysters, ants, turtles, frogs, snakes, jellyfishes, grasshoppers, dogs, robins, flies, lizards, salamanders, crayfish, clams, butterflies, toads, ducks, and corals. Suppose you tried to sort them into groups.



You might start with cows and put with them the animals that most resembled them. Let us see. Cats are somewhat like cows, but codfish are very little like cows. Let us put the cats with the cows. Go through the storeroom. Mackerel are somewhat like codfish. Let us place them together. Mice—like cows rather than like fish. Moles—like mice and therefore somewhat like cows rather than fish. Sharks—put with the fish. Eels—with the fish. Bees—not like any of the others so far. Let us start a new group. Doves—will not fit into any of our groups. Let us start another group. Hawks—with doves. Crabs—do not fit in; so let us start another new group. Starfish—another new group. Earthworms—another group. Bears—they have fur somewhat like a cat and four legs and claws. Let us put bears with cats and cows. Deer—with cows. Lobsters—with crabs. Flatworms—well, let us put them with earthworms. A scientist might not agree with us, but they are more like earthworms than they are like any other of our groups







so far. Oysters—very different from any so far, a new group. Ants—somewhat like bees. Frogs—they do not fit in, a new group. Snakes—we cannot fit them in, so another new group. Jellyfishes—nothing like them so far, a new group. Grasshoppers—with the bees and ants. Let us head this group *Insects.* Turtles—they have scales somewhat like snakes. Put them with snakes. Dogs—with cats and cows. Robins—with birds. Flies—with insects. Lizards—scaly animals like snakes. Let us call this group the *Reptiles.* Salamanders—if you know these pretty little creatures, you know they have smooth skins like frogs. Put them with the frogs. Crayfish—like crabs and lobsters. Clams—like oysters. Butterflies—insects. Toads—with frogs. Ducks—birds. Corals—that is a puzzle. If you ask the museum scientist who studies animals, he will tell you to put them with jellyfishes.

Now let us examine our groups and arrange the groups in order. Our first group was cow, cat, mice, moles, bear, deer, dogs. What groups have some resemblance to them? We might pick out fishes, frogs, reptiles, birds. They are more like the cow-cat groups than are any other of the groups. All these animals have backbones and none of the other groups have backbones. Let us call them the *backboned animals* or, in more scientific language, *vertebrates.* All the other groups are *invertebrates,* which simply means they are not vertebrates.





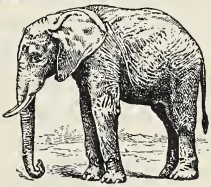


Reptiles

Now let us look over our groups of vertebrates, and put the various groups of vertebrates in order.









Mammals

We should say that the most highly-developed of the group of vertebrates, the most *up-to-date*, is the cow-cat-dog group. We should probably agree that the simplest of the vertebrates are the fishes, for they do not even have legs. It is true that snakes do not have legs, but let them go for a moment until we see something more about them. Now we still have three groups of vertebrates to put in order between the cow-cat-dog group and the fishes. These three groups are the frog-and-toad group, the reptiles, and the birds. You will probably agree to put the birds next to the cow-cat-dog group.

Getting a name for a group of animals. Now let us pause for a moment. "Cow-cat-dog group" is a clumsy expression. Can we not get a word for the whole group, just as we have one word for the fishes, another for the reptiles and another for the birds? Perhaps you are not familiar with a suitable word. Certainly we need a word. The group of animals have several things in common. They have fur, and no other animals have fur. To the scientist, however, the most interesting thing about these furry animals, including the cow and the deer, is that they give milk to feed their young. No other kind of animals give milk. The milk is manufactured in the body of the animal in glands called *mammae*,

therefore, this group of animals is called the *mammals*. Remember that word *mammal*, and learn how to spell it. The mammals are the highest, most intelligent group of animals. When most people say animals, they mean mammals, but you have seen that there are many other kinds of animals. Therefore, hereafter, let us call these fur-bearing, milk-giving kinds of animals, *mammals*.

Now we will return to our task of grouping the animals in the museum storeroom and arranging the groups in order. We were working on the vertebrates and we decided that the fishes were the lowest vertebrates and the mammals were the highest vertebrates. We placed the birds next below the mammals. That leaves us two groups of vertebrates to put in order, the reptiles and the frog-toad-salamander group.

Now we shall need to pause again and get a more convenient name than frog-toad-salamander group. Here the scientists chose a word that tells how the creatures live. In your studies in autumn and in spring, you learned, if you did not know before, that frogs and toads live in the water when they are young tadpoles. When they grow up, many frogs leave the ponds and wander around in the damp places. Toads leave the ponds and do not go back until it is time to lay eggs. Then they must go back, for the young tadpoles must have water to live in. Salamanders also hatch out of eggs laid in the water. As young they are tadpoles that swim around the water and breathe by gills. When they grow up, some salamanders leave the water and live for a time in the woods, but they must return to the water to lay their eggs. The animals of this group live both water lives and land lives. The scientists therefore call them *amphibians*, from two Greek words meaning "both lives." Learn that word *amphibians*.

It is a very convenient word. Learn to spell it. You know now what it means.

Putting the vertebrates in order. Once more we go back to our museum storeroom and finish arranging the groups of vertebrates: highest, mammals; next highest, birds; lowest, fishes. We must decide which is lower, amphibians or reptiles. Now you would need to know something about the bodies as well as the lives of the animals of each group. Tadpoles breathe by gills and fishes breathe by gills. Reptiles do not have tadpoles or gills and the higher vertebrates, birds and mammals, do not have tadpoles or gills. There are also some other things about their body structure that make the amphibians lower animals, more like the fishes. Therefore, let us put amphibians next to fishes. Then we have the vertebrates group arranged in order: fishes, amphibians, reptiles, birds, mammals.





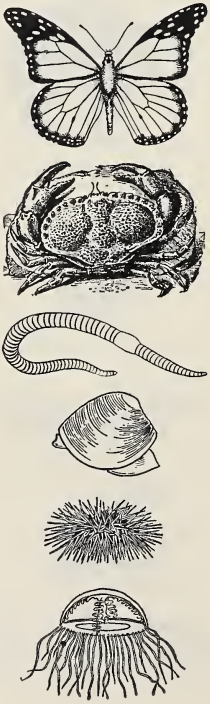






Putting invertebrates in order. Now let us look over the invertebrates. There are many more kinds of invertebrates than of vertebrates. There are over six hundred thousand kinds of insects alone. That is more than the number of all the different kinds of vertebrates. There are only about forty thousand kinds of vertebrates. As we look over the invertebrates, we notice that some kinds have legs and some kinds

do not have legs. We should not hesitate to say that a bee or a butterfly is a more complicated animal than a jellyfish. Let us put the complicated invertebrates highest. The invertebrates with good legs are insects and the crab-lobster-crayfish group. The insects are more complicated than the crab-lobster-crayfish group. Most insects, for example, have wings in addition to legs. Let us put insects highest. We will put the crab-lobster-crayfish group next, but we need a good name for the group. The name of the group is *crustaceans*, from a Latin word which means "shell." So we have highest invertebrates insect, second highest crustaceans. Then worms have bodies somewhat like insects without legs. Let us put third, worms. Next: oysters and clams, snails and some more such animals. They have soft bodies and many of them have hard shells to protect their soft bodies. Because of their soft bodies they are called *mollusks*, from a Latin word which means "soft." Next put down starfishes and their cousins, the sea urchins. They are the spiny-skinned animals [called *echinoderms*]. Last and simplest in the list we mentioned at the beginning of the chapter are the jellyfishes.



The first animals. We have not yet come to the simplest animals that should begin our list of groups. Most people

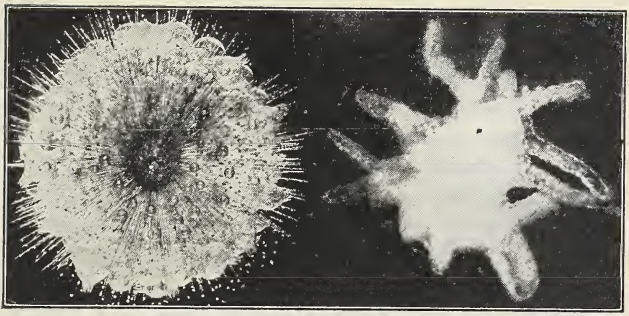
have no name for these tiny creatures because they have never seen them. They are all about us nevertheless. They are in all sorts of water and in the dampness of the soil. We drink lots of them probably and may eat them with our food, if the food is not very carefully handled. Some of them can live inside us. Some are found in the mouth and others in the intestine and other parts of the body. Some of them cause disease and death. Most kinds are harmless. The oceans and the fresh waters swarm with them. They are much too small to see if one is alone, but when the vast numbers assemble on the surface of a pond they sometimes color the water green. You cannot see one of these animals without a microscope. They are the simplest animals of all. They are called *protozoa*, which means "first animals."

Many scientists study the protozoa. They are fascinating animals. Think of one microscopic cell, less than one one-hundredth of an inch long. It moves about, crawling or swimming, finding and eating its dinner, finding the best place in the pond or the drop of water to live, where it is not too hot or too cold, where there is enough light and not too much, where there is air to breathe. Some of them eat microscopic plants, as rabbits eat plants. Some eat other protozoan animals, as wolves eat rabbits. If you have a microscope at school or if you can get one next Christmas, you may look into this active, whirling, world of microscopic things. You will find it lots of fun hunting the protozoa in drops of water from pools, wet dirt and almost anywhere else where there is a little wetness. You can have lots of fun learning their names, for they do not have common names, as common folk do not see them.

You have probably heard of one protozoan, the *amoeba*. Its picture often is met in books and

magazines. When you see it first, it looks like a little bit of rather clear jelly. You probably will pass it by, but if you are suspicious, watch this tiny blob of jelly. After a little you may see the jelly flow out slowly in a long finger. This finger is called a *false foot.* [If you prefer, the scientific term is *pseudopodium*, which means "false foot."] After a little the whole amoeba has flowed into the false foot and the animal is in a different place. By this time another false foot is flowing out somewhere else. So the animal travels around, slower than a snail. The animal seems to know food when it is in the drop of water, and flows over to it through its successive false feet. It puts out a false foot to touch the food particle, and then just flows around the bit of food and the food lies inside the body. You cannot see just how the food got inside.

Amoebas have a very simple way of raising a family. When the amoeba grows big enough, it just divides into two blobs of jelly, and there are two amoebas. Most protozoans produce new protozoans in this way. Some of them do so very rapidly. One little animal that you can easily get by putting some dead grass in a glass of water and waiting a week is the paramecium. When there is plenty of food and good water, the paramecium will divide into two paramecia every few hours. At that rate it does not take long to get swarms of paramecia in your glass of water. If that went on in the pond, it would not be long before the pond was solid paramecia. But nature never gives any animal—not even man—its own way very long. There are many things that eat paramecia. A deluge of rain may take them out of the pond. The pond may dry up. The growth of other living things may kill them. The water may become foul and kill them.



Ewing Galloway, N. Y. *Keystone View Co., N. Y.*

A deep-sea protozoan and an amoeba

Some of the protozoans are very ornamental. The picture shows one of the striking kinds. Many live in the sea. Their skeletons, when they die, drop slowly down to the bottom. Great plains on the ocean bottom are covered many feet thick with an ooze composed of protozoan skeletons. Some of these protozoans make their skeleton of limy substance, chalk. Others make them of sandy substance, silica. You can sometimes find these animal skeletons by carefully washing a new sponge. The fine sandy substance that is washed out frequently contains the skeletons.

Man is benefited by some protozoans and made sick and even killed by others. Many protozoans of the sea are eaten by larger protozoans. These larger protozoans are eaten by animals a little larger, perhaps small crustaceans. These in turn by larger crustaceans or small fish which are the food of our commercial fishes. So when you eat codfish or herring next time, think that perhaps their good white meat was once the substance of protozoa.

Some of the worst diseases that man has to contend with are produced by protozoans that live in the body. The deadly sleeping sickness of Africa is due to

protozoans that live in the blood and in vast numbers plug up the capillaries of the brain, producing the sleep that ends in death. Malaria is due to another protozoan that lives in the red corpuscles of the blood and destroys them. Other protozoans produce disease in cattle, dogs, rabbits, chickens, and many other animals, including insects. Insects carry some of these protozoa to man. Malaria is carried to man by mosquitoes, African sleeping sickness, by the tsetse fly.

Animals arranged in order. Now after our digression to study something about the simplest group of animals that we could not find in the storeroom of our museum without a microscope, let us return to our job of arranging the groups of animals in order. We shall begin with the simplest, as the scientist does. We shall write the groups in a table.

TABLE OF GROUPS OF ANIMALS IN THE WORLD

The Invertebrates

1. Protozoa
2. Jellyfishes, corals and their relatives
3. Starfishes and sea urchins (echinoderms)
4. Oysters and clams and snails (mollusks)
5. Worms
6. Crabs and lobsters—crustaceans
7. Insects

The Vertebrates

1. Fishes
2. Frogs and toads—amphibians
3. Snakes and lizards—reptiles
4. Birds
5. Mammals

We have left some groups out of this table. The scientist would not be satisfied with such a table, but we have many kinds of animals represented by these groups, many more than any scientist knows all about.

Putting plants in order. In the same way we can arrange the plants of the museum—or of the world—in groups. We shall be brief, however, for the chapter is now too long. The simplest plants are plants of only one cell, corresponding to the animals of only one cell. When you get your microscope for Christmas, you can scrape some of the green stuff off the damp tree trunks and see one of the simplest plants—just a round green cell. The green slime on ponds is made up of more of these simple plants. Like the Protozoa, they also live in the sea, floating, like the Protozoa, in the upper waters. Just as the green plants of the land support the animal population, so the green one-celled plants support the animal population of the sea. You remember the place of the protozoans in the food story of the sea. We did not begin that story at the beginning. The beginning is the green one-celled plants that float in the sea water. They are the green pastures of the sea. The big cousins of these one-celled plants are the seaweeds, and some of them are big, really big—900 feet long. But the seaweeds are very simple plants. They have no roots, stems, leaves, flowers, wood, or bark. We must have a name for the group of simplest plants. The name is *algae*, from a Latin word which means "seaweed."

Molds and Mushrooms. Mold grows on foods. Perhaps you set your wet shoes in the cellar and found them the next week covered with mold. Molds seem to come anywhere there is a little dampness. Did it ever occur to you to ask where they come from? They come, of course, from other molds just as all oaks come from other oaks and all cats come from other cats. Living things come from other living things of the same kind. Molds are very simple little plants. They are just white threads, even the

black molds and the green molds. You will need a microscope to see the threads. In mushrooms and toadstools, which are distant cousins of the molds, there are so many threads that they make up the stalk of the mushroom. Underground the mushroom has many rootlike threads that are very fine. If you dig up a mushroom you can see some of the bundles of threads that look like roots. If you take off the cap of a mushroom that has expanded, and place it overnight on a sheet of white paper, you will find, when you gently raise the cap next morning, that a design like a wheel with fine spokes is on the paper. If you pick up the paper, the design just slips off. Under a microscope you can see that the design is made up of fine dustlike particles. They are the bodies that start the new plants as seeds start flowering plants. They are called *spores*. The mold starts because its fine, dustlike spores are floating almost everywhere in the air. When they fall on some moist food, they start to grow. The black, green, and other colored molds are due to the color of the spores.

This group of plants is called *fungi*, from a Latin word which means "mushroom." They differ from the ordinary green plants that you see everywhere about you by not being green. They cannot, like green plants, make their own food from the minerals of the soil. They live on dead stuff or on living things. Many kinds of fungi live on our crop plants, garden flowers, and orchard trees, causing the sickness and death of the trees and other plants. Many fungi live on the dead leaves and dead branches in the forest and cause their decay. In that work they are of help to us, for if dead things did not decay, the earth would be covered with dead plants and animals.

Bacteria are also little plants that feed upon other plants or upon animals. They are so tiny that a

good microscope is needed to see most of them. As you know, some kinds of bacteria are disease germs. Some of these disease germs live in the bodies of human beings and other animals. Some of them live in other plants. They cause much of the sickness of the world, sickness of both animals and plants. At the beginning of this chapter some of the germs of disease are shown. They are the streptococcus, the anthrax bacteria, and the diphtheria bacteria.

Did you ever look at **moss,** really examine it carefully? You will find it has tiny leaves. At certain times a thin threadlike stalk stands up from the end of the stem holding a little case at the top. With your microscope you can see that the case contains spores. Spores start new moss plants. The mosses form another group of plants.

Ferns are the next group. Did you ever notice on the back of a fern leaf, tiny little dots, green or brown? They are made up of little rounded cases. With a lens you can see the cases. With a microscope you can see spores that come from the cases. When spores are ripe the cases burst open and the spores are scattered by the wind. [This group is called *pteridophytes*, but you need not remember the name.]

The next group, and the highest groups of plants, is the **seed plants.** Most of the plants that you see about you belong to the group of seed plants. You know by your earlier study that seeds arise in flowers. Did you ever see the flowers of grasses or of oak trees? Look for them in the spring. You may find flowers of one kind of grass or another all summer long from early spring to late fall.



Spore cases of a fern

Now let us put the groups of plants in order, starting with the simplest plants.

Plants of the World

1. Seaweeds, pond scums and other microscopic green plants, algae
2. Bacteria
3. Toadstools, mushrooms, yeast, and many other colorless plants, some of which cause diseases of higher plants. Fungi
4. Mosses [called *bryophytes*, "moss plants"]
5. Ferns, horsetails, and club mosses (pteridophytes)
6. Seed plants

How to Study about Arranging Things in Order

I. Read the chapter.

II. The best way to get the ideas behind the chapter is to write down the names of a great variety of plants and animals, each one on a piece of paper (or get their pictures) and then arrange them in groups such as was suggested in the chapter. Get a name for each group as suggested. Arrange the groups in order of increasing complexity. Similarly arrange groups of plants.

III. Test yourself with these questions:

1. You can choose color, size, or shape or any other character with which to arrange animals and plants. What characters do scientists use in such arranging or classifying?

2. Write down a list of the main groups of plants and the main groups of animals, with examples of each.

IV. Think out or investigate these questions:

1. What group of plants is best adapted to live in the sea? What group does not live in the sea?

2. What group of plants is most useful to man?

3. What group of animals is most useful to man?

V. Vocabulary. There are many strange words in this chapter. You need learn only the following:

vertebrates	protozoa	amphibians	reptiles
crustaceans	mollusks	mammals	fungi



UNIT X

THE CONSERVATION OF OUR NATURAL RESOURCES

"UNCLE SAM is rich enough to give us each a farm," was once a common saying. In the East, land was to be had for the clearing away of the forest. Then over the Alleghenies in the Old Northwest, more good land was given away or sold for fifty cents an acre or less. Then the rich land of the prairie States was taken up. Westward still the edge of the Great Plains was turned under by the plow. By that time the westward urge had carried settlers to the Pacific coast. A great empire of rich land was heavy with crops. Beyond lay the Pacific. Then the tide of settlement turned back and flowed back into the valleys that had been passed by when the great westward migration drove covered wagons to the end of the trails, and then still onward. It was realized that the best lands had been taken up. The government was still giving away land to anyone who would settle on it and stay there. But now a new saying had become common, "The government is willing to bet you a hundred acres that you cannot live on it for a year."

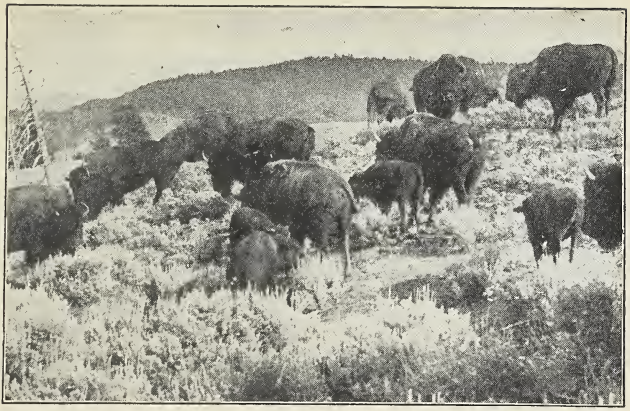
When the good soil that nature had fertilized by the dead forest leaves of countless centuries was cleared of woods, little thought was taken of keeping it fertile. There was plenty more land westward to be had for some hard work, and settlers and farmers do not mind hard work. Crops were grown year after year with little thought of keeping the soil fertile. Good, fertile soil was allowed to

wash down the hillside with each rain. Eventually the stony subsoil was laid bare by the plow and the rain wash. The land was abandoned and new land was cleared, to be abandoned in turn. When the plow reached the Great Plains, miles upon miles of sod were broken, the soil laid bare and planted with wheat. When there was rain enough there were crops. When there was no rain, there were no crops. Then the winds picked up the good, fine soil and whirled it away, and nature's work in making good soil was undone. Uncle Sam has no more good land to give away.

When the magnificent forests were being cleared from the lands of the East to make farms, no thought was taken of the lumber beyond the little needed to build houses. Oak trunks, centuries old, were piled up and burned to get rid of them. There was no market for the lumber. Now the railroads have reached the hidden corners of the mountains and hills; steamships call frequently at the ports; motor tractors haul out logs to rivers and railroads. Now has the waste of lumber stopped? Not at all. In the forests of Oregon, great hemlocks and other trees are uprooted and destroyed to get them out of the way of felling and hauling of the more valuable Douglas fir.

When the first oil wells were drilled in western Pennsylvania, men gathered around when a gusher shot a great deluge of oil high into the air and were delighted to see the waste of thousands of barrels of oil that ran away down the streams. Loss from a gusher does not delight the oil men today. They see the waste. But drilling of the ground above one oil pool with hundreds of wells and rushing the oil on the market, is waste. We are wasting oil, and when it is gone there will be no more. Coal also is being wasted, millions of tons a year. Coal in the earth will last longer than the oil, but the end is sure.

Many other minerals are wasted. There seems to be plenty of iron, but not so of copper, zinc, and tin. These latter three are very necessary in the modern world. We bring minerals from the jungles on the other side of the earth, and we waste them when we get them here. Can the waste be stopped? It can.



Ewing Galloway, N. Y.

CHAPTER FORTY-ONE

DESTROYING THE WILD THINGS

The passing of the buffalo. No more astounding story was ever told than the story of the buffalo. For thousands of years the Indians of the Plains had lived with the buffalo before the Spanish and the French explorers penetrated to the Great Plains and the Prairies and saw the vast stretches of rolling land covered black with buffalo as far as the eye could reach. No one knows how long the Indians had depended on the buffalo for their livelihood. Their food, their lodges, their clothes, their ropes and string, and many other articles came from the buffalo. Anything that would have killed all the buffalo would have killed the Indians. Every spring the great herds came up from the Plains of Texas and tramped slowly northward into Canada. All along the long march different tribes of Indians had their hunting grounds. If for any reason the great herds were turned out of their usual line of march and did not appear in the hunting grounds of a tribe, that tribe faced starvation. The wars between the Indian

tribes of the Plains were wars for hunting grounds where the buffalo came. All summer the Indians hunted, skinned, and dried and smoked the meat over slow fires. Then they packed the dried meat away in bags made of buffalo hides. The hides were scraped free of flesh, cured, and worked soft for the making of blankets, clothes, and lodges. When the last of the great herd had gone south for the winter, the Indians settled down in sheltered valleys for long months of cold weather to dried buffalo meat and eternal watchfulness for their enemies.

On this buffalo life of the Indians the white hunters came. At first there were only a few white trappers and traders. They shot what they needed of the buffalo for food and robes and passed on to the mountains for more valuable furs. They did no harm to the great herds and generally were on good terms with the Indians, often living in their lodges. They returned to the frontier posts at intervals with their furs and tales of the great herds.

Then came the settlers. Great wagon trains passed westward across the land of the buffalo. The Indians began to take alarm at the great number of the white strangers invading their hunting grounds. They had good reason to become alarmed. After the first wagon trains of settlers came the buffalo hunters. The Indians saw with amazement thousands of buffalo shot, stripped of their hides, and the good meat left to feed the wolves or rot in the sun. Wagon trains of hunters and traders pushed out on the Plains to kill buffalo and to buy skins.

The first railroad pushed out across the Plains. Trains were stopped by the passing herds that for hour after hour streamed across the tracks. Travelers left the trains with their rifles, shot, killed, and let the dead animals lie, not taking even their skins.



H. Armstrong Roberts, Phila.

Deer, long threatened with extermination, are now increasing

They killed the magnificent animals for the sheer love of killing. The Indians were doomed. They saw their great herds dwindling and disappearing. In an astoundingly few years, the vast herds were gone. The Indian faced death by starvation. Only the government, stepping in to stop the Indian wars against the white settlers, saved the Indians from starvation by feeding them on the reservations.

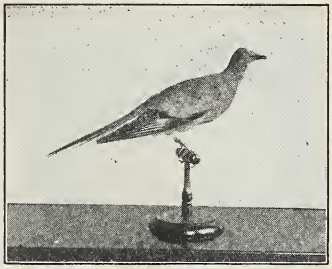
The farms of the prairies and the Plains could never have developed with the great herds of buffalo marching across them. Even the herds of cattle could not have been raised on the Plains until the marching herds of buffalo marched no more. The vast herds of magnificent animals had to go. Yet before the last few buffaloes were killed and the animals lost forever from the earth, men began to demand that the remnant be saved. Some were gathered on reservations. The herd on Yellowstone reservation, protected from destruction, has prospered and grown. Now they have become numerous. There is not enough pasture in the reservation to provide food. The government is taking steps each year to reduce the herd by giving the surplus animals to those who will take care of them. In the Canadian buffalo park, the herd is reduced by killing off the surplus buffaloes and giving the meat to the Indians.

Deer and bear. East of the buffalo region, other animals supported the Indian population in the days before the white settlers took the land and destroyed the native animals. Deer and bear formed an important part of the living of the Indians. Deerskin made good clothing. The white backwoodsman found it so good that in the days of Daniel Boone deerskin hunting shirt and trousers were the regular dress. Bearskin made warm rugs and bedding. When the settlers came in, deer and bear were destroyed. Now over thousands of miles of the native land of these animals, people have never seen either.

In other parts of this land, however, in the mountains and the forests, deer now are protected. Their natural enemies have been killed off, and with only a few days of hunting allowed each year, the deer have multiplied so rapidly that now there is not enough winter food for them. Furthermore, farmers in these areas frequently have their vegetable gardens raided and destroyed by deer. Bears also are protected in much of this area, hunting being allowed for a short time each year. But there are not so many bears. They kill other animals for food, and the killers among animals are never as numerous as the animals that they kill. Bears also are dangerous and more destructive and their number is kept down in farming regions.

The loss of a great race. Sadder than the lot of the buffalo was that of the passenger pigeons. In the Indian days and the days of the early farmers in western Pennsylvania, Ohio, and the States to the west and south, the flights and roosts of wild pigeons were watched with eagerness, for pigeons were valuable additions to the food supply. Flights of pigeons shut out the sun and the roar of their wings was described by an observer as loud as the roar

of a broken mill dam. They roosted in such vast numbers that their weight broke off the limbs of large oak trees. Their numbers brought their death. Men gathered at their roosts from hundreds of miles. They slaughtered them with guns and clubs at night. Wagons were loaded. Finally when the hunters had all they could carry away in wagons, thousands more were slaughtered and hogs were driven in to feed on their dead bodies. The end came swiftly. Now not a passenger pigeon is alive in the world. The race of birds that the Indians used as food for thousands of years was totally wiped out in a few years.



Hugh Spencer, Chester, Conn.
The last of the passenger pigeons

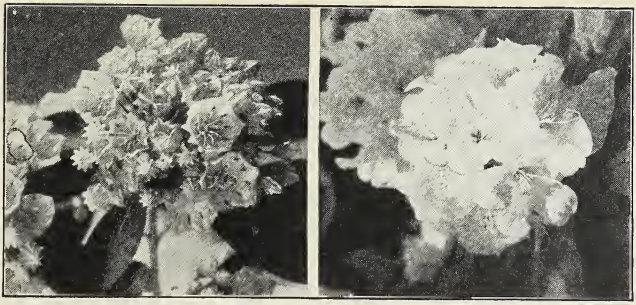
Will the ducks go? Will the ducks follow the passenger pigeons? Ducks, too, were important in keeping the Indians from starvation. Within the memory of men now in middle age, vast flights of ducks blackened the bays and the ocean waters off shore. Some restricted localities are still visited by great flights, but hundreds of miles of their former feeding and resting grounds have now only a few scattered ducks or none at all. The slaughter goes on. Each fall the ducks run the barrage of guns from Canada to the Gulf of Mexico. In the northern part of their range, they are shot in October; a little further south in November; and still further south in December. Although ducks may be shot for a month in any one locality, the migrating ducks are liable to be shot "lawfully" for four months.

It is little wonder that several kinds of ducks are almost extinct, almost gone forever from the earth.

All sorts of trickery are used to lure the ducks to destruction. Water in the marshy land is baited with food and the hunters lie in hiding. Live ducks are used to decoy them into the dangerous water. The ducks are going from the earth due to the same destroyer that wiped the passenger pigeons from the earth and almost wiped out the buffalo. One thing only can save them. Stop shooting them until their numbers are again built up.

Other losses. Many other animals might be mentioned that were valuable in supporting the Indians, and now are rare or unknown in many parts of their former range. Wild turkeys were important food for the early settlers but now they are gone except a few of them in the wilder parts. Our native pheasants, the ruffed grouse, are unknown in most parts of their former country. Even squirrels have been made so scarce that one in a day is noticed in the country where the backwoodsman could pick up his rifle before dinner and in a few minutes bring in a squirrel. Even songbirds, where they are not protected by active police and game wardens, are absent.

Another sad story is that of the fur-bearers. Beaver, mink, fisher, marten, racoon, and fox, as well as bear and wolf, have been followed to the uttermost parts of the wilderness. Many of these have disappeared entirely from the farmed regions or even the woods and mountains of the East. Now they are threatened in the uttermost parts of the northern woods and the barren grounds beyond. Trappers are dropped by airplanes on the frozen lakes. They get every fur in the territory if they can, then are picked up by the plane and carried to a new part. The Indians never took every animal. They always left some for seed, for they knew full well that next year and the years to come, animals of the forest must supply them



Hugh Spencer, Chester, Conn. *H. Armstrong Roberts, Phila.*

Mountain laurel and rhododendrons are protected by State laws

with clothing, lodges, bags, ropes, as well as food, and fur to trade with the white man. Now the Indians of the far North who had made a living in the woods are being fed by the government.

Destruction of wild flowers. Not only have our forests disappeared needlessly but the lovely and beautiful plants have gone too. Orchids of several varieties formerly bloomed around the country close to the eastern cities. They are gone. Many other of the beautiful wild flowers have given place to weeds. Laurel and rhododendron that recently covered the mountains are being ruthlessly dug. Some of this digging is by those who know how to transplant the bushes. Much more is done by careless persons who think they have found something that they can get for nothing. That the plant dies after being carelessly dug out, does not trouble them. Much of the laurel and rhododendron that is sold, is taken from land without the permission of the owners of the land—stolen. The natural beauty of the country in most places is being destroyed ruthlessly. Why? Even the road-builders who seek to attract tourists to their region take little thought of the natural beauty when the road is built. Beautiful

trees are cut down and bare slopes left in their place to be shortly covered by unsightly weeds. Winding roads through pleasant valleys are replaced by straight, ugly stretches of concrete, unsightly fills, and equally unsightly cuts.

Things to Do in Learning about the Destruction of the Wild Things

I. Read the chapter.

II. Study wild life.

1. Make a study of the wild life in your region. The best way is to go out in the fields and woods and along the seashore. What animals and birds do you see still alive and wild? Then go into the library and learn what animals formerly lived in this region and are now seldom or never seen. In most parts of the country there are many kinds of wild animals that are not seen by city people who visit the country and even by the farmers who are busy on their farms. Learn how to see them. If you live in the city, you may be surprised at the list of wild animals that can be written down as inhabitants of or visitors to your city.

2. What animals of your region are in danger of extermination? How may they be saved? Did the animals mentioned in this chapter ever live in your region? Have other animals been exterminated in your region? How did the extermination come about?

3. What animals once in your region were exterminated by the settlers in order to establish farms? Why was each exterminated?

4. Make a study of the wild life that is destroyed by "improvements" in creating and developing farms; in developing towns; in building roads. What plants and animals are destroyed? Is their destruction necessary for the "improvement"? Is their loss any loss to us? How?

5. What plant life has been destroyed unnecessarily? You know enough about the history of the country to name some plant life that has been seriously reduced or has

vanished from many regions. Why has it been destroyed? Learn the names of some of the beautiful plants that have been largely destroyed in the regions in which you live or which you visit. Name some plants of your region that should not be gathered because they are in danger of being exterminated.

III. Test yourself with these questions:

1. Name some animals that have been exterminated.

2. Name some animals that have been so seriously reduced in numbers that they are in danger of extermination.

3. Why are certain wild plants in danger of extermination? Can you name any such plants?

4. How do "improvements" endanger wild life? Can provision for saving the wild life be had when "improvements" are made?

IV. Think these out or investigate:

1. What wild animals affect your life? Think of the tiny animals as well as the larger ones.

2. Do any wild animals live in or about your house? Even if you live in the city you may find evidence of wild life.

3. Can you learn on what wild life the following natives largely depend where they have not become dependent upon the white man? The Eskimo, the African pigmy, the Australian "black fellow."

4. Can you learn of animals that have been exterminated in other countries?

5. What animals have the United States Government or the government of your State destroyed?

6. What products from wild animals may be replaced by other products and thereby save the wild animals?

7. Why is it desirable to save the wild life? Do not answer this question hastily, you may think of some unexpected values of wild things.

V. Vocabulary. Have you any new words?



Ewing Galloway, N. Y.

CHAPTER FORTY-TWO

BRINGING BACK THE WILD LIFE

How the bobwhite came back. Forty years ago, every fall men took their dogs and guns and went to shoot quail in Ohio. So famous as a shooting ground for quail had the fields of Ohio become that gunners came from as far away as New York and Chicago. At one house in a certain village where four men were accustomed to gather in the gunning season, it was expected that a washtub would be filled with quail each night. Before the end of the visit everyone was tired of eating quail. To a thousand other houses gunners were bringing big bags of quail. The end was inevitable.

No more the cheery call of "bob white" came over the fields in the springtime. No more the trim little birds ran across the dusty road ahead of the buggy. No more the bobwhite mounted the rail fence just behind the garden with the morning sun lighting his beautiful body as he whistled out his welcome call. No more the fluffy little balls of young quail the size

of the first joint of your thumb ran for shelter in the grass or squatted down in plain sight. The quail seemed to be on the road that the passenger pigeon had gone before.

Then the lawmakers acted in response to popular demand. Bobwhite quail were declared to be song birds and their shooting stopped. Five years later, the quail were coming back. Their lively call again rang over the fields. The males again stood up on the rail fences. The little flocks again ran trimly across the road and came into the village back yards. They had been saved by stopping the shooting before it was too late. In a certain Florida district, the people decided that they would rather see the quail alive than eat them dead. Shooting was stopped and in a few years the birds were about the villages.

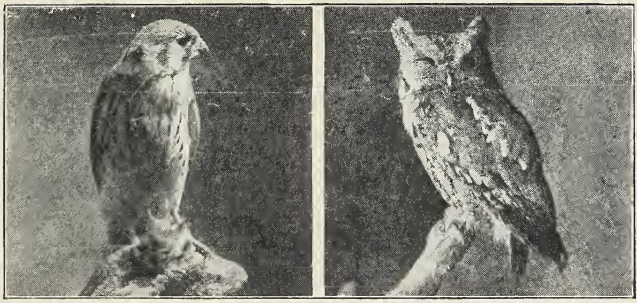
Quail are valuable birds—when alive. They eat great quantities of weed seeds. And they eat many times a day. Birds, especially active out-of-door birds, not canary birds in cages, have big appetites. They need to eat rather constantly to keep themselves active, for flying is hard work, using up a lot of fuel whether in bird or airplane. The bird's fuel is food and he must have it in large quantity. The quail's food is seed, and the seed that is available in large quantity is weed seed. Protection of these valuable birds helps the farmer in his endless battle with weeds.

Saving the birds. Songbirds are valuable birds. They of course add joy to life when you hear them about the dooryard or over the meadow and along the woods. A great part of the joy of a springtime hike is in the birds you hear and see. A flash of bright plumage red or blue, orange or yellow and a more leisurely view of the beautiful graduations of color in many of our common birds add to the beauty of life.

Most important of all to everybody, even to those who can see and hear no beauty in life, birds make food cheaper and more plentiful. They are tireless enemies of our great enemies, the insects, as well as our enemies the weeds. Many birds eat only insects. Their lives depend upon finding insects. Most land birds feed their young on insects. Even the great numbers of different kinds of native sparrows, song sparrows, field sparrows, vesper sparrows, tree sparrows, white-throat sparrows, most of them good singers, feed their young with insects. The sparrow's food is weed seed, but the baby sparrows must have meat, and meat for sparrow babies is insect meat.

The millions of sparrows, quail, pheasants, and other seed-eaters feed chiefly upon weed seed. Weeds are constantly struggling to overtop and undermine the crop plants, and without the constant work of the farmer in defense of his crops, the weeds would crowd them out. The great multitudes of birds are keeping the weeds under control.

Another set of birds needs our constant protection. Although they are among our best friends because of their destruction of our enemies, the gun of every hunter—almost every hunter—farmer and even game warden is aimed at them. Where they have been killed off, rats and mice have overrun the country and devoured the crops. These good bird friends of ours are the hawks and owls. Three kinds of the many kinds of hawks will kill chickens and game birds, if they get the chance. They also will kill mice and rats. There are plenty of rats and mice and relatively few chickens for the hawks to reach. If a hawk has developed a habit of visiting the chicken yard, there is nothing to do about it except to get the gun and then the hawk. But seldom are the hawks around where the chickens are. The hawk



Hugh Spencer, Chester, Conn.

The hawk and the owl destroy many mice

sailing over the meadow is looking for meadow mice. The mice breed in such numbers that there are always plenty to be had. The few chickens that the hawks get is a small price to pay for the good work of the great numbers of beneficial hawks and owls.

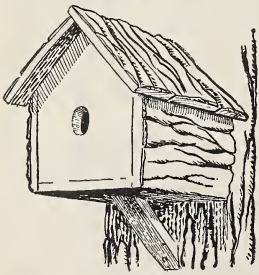
How to help the birds. Birds need food, hiding places for their nests, and safe places to spend the night. They also need water. If you provide these things and protect the birds from cats and guns, the birds will come around. Bushes, trees, and tall plants attract the birds. Seeds and fruits on trees, bushes, and lower plants bring the birds that eat them. Bushes with berries such as sumac and bush honeysuckles and highbush cranberry are the things to plant to attract the birds. Wild cherries are eaten by many kinds of birds. Sunflowers produce seeds in abundance, and goldfinches, among others, gather around to enjoy them.

A tangle of bushes and dense trees furnish safe roosting places and nesting sites. The birds will not stay unless they are safe at night and find safe sites for their nests. Cedar and other evergreen trees shelter many nests. Dense tangles of vines and bushes are also safe places for nests.

An old gentleman sold a farm on which he had done no farming but had enjoyed the birds and other wild things. He had allowed the bushes to grow tall close to the house and around the fences. Birds were everywhere. They came and fed from his hand. The new owner of the farm started to "clean up" the farm, not to farm it but to enjoy it as a country residence. His men cut down all the bushes along the fences, mowed every fence corner, pruned almost to the ground the tall shrubs around the house, and dug out sumacs and wild cherries.

Next summer there was hardly a bird near the house. Their shelter was gone and most of their food. No safe hiding places for their nests could be found. The phoebes that had nested on the spring house were driven away by alterations. Bluebirds found their nesting boxes gone. The house wrens found no nesting boxes. All about the little brook that flowed from the spring across the lawn were myriads, clouds of little flies that had never been known under the previous owner. Phoebes and other flycatchers had gone to safer, quieter places.

Put up nesting boxes for the birds that use them. Many kinds of birds, like the house wrens and the bluebirds, use houses and boxes. Put up ledges with overhanging roofs for robins and phoebes. The picture shows a wren house.



A wren house

All birds use a birdbath if there is no supply of water close at hand, and many prefer the birdbath. They do not always use the bath for bathing, but often for a drinking fountain. Just a pan of water placed out of reach of cats is all that is necessary. You may make

it as artistic as you wish. You may be surprised by the number of birds that come for a drink.

In winter food may be scarce, especially if snow is on the ground. Then set up feeding stations. An open platform with a roof to keep off the snow is all that is needed. Put it above the reach of cats and in a position where the birds can have a clear view of all that approaches. When a bird can see about, it seems to feel relatively safe. Many birds may be shy about entering a dark place from which they cannot see the approach of an enemy. When snow lies long on the ground many birds may have a hard time finding food. Shelters like open-end tents made of wood are often placed in the woods with corn and other seeds for the pheasants, quail, and other seed-eaters.

Furnish protection for birds from their enemies, cats, boys with air rifles, and men with shotguns. The law prohibits the shooting of songbirds and those that eat insects, but a person so disposed can often get a shot at a bird. A little education will help the gunner with air rifle or shotgun to see the beauty and value of birds.

Often a word to the one who intends to shoot, will save the birds. At a little hotel in the woods an overnight guest with a rifle asked a workman if the law prevented his shooting a heron that was standing at the water's edge a short distance up the lake shore. "No," said the workman, "go ahead, shoot it." A woman who had been all summer at the lake, heard the remark. She immediately went to the rifleman. "I have watched that pair of herons all summer. They are beautiful and they add to the beauty of this lonely lake. You shall not shoot them." The man shamefacedly put away his rifle. Your word will often save the lives of birds. Speak up.

Game refuges. Saving the ducks and geese has become a matter of interest to the Federal and State governments. Associations and landowners have also joined in the effort to save the ducks. On their long spring and fall flights the ducks need places to rest safe from guns and places to feed. Marshy ponds and bays furnish food and resting places if they are protected from gunners. Large tracts of marsh land have been set aside by the government as refuges where no shooting may be done. These refuges are located along the lines of travel of the birds, so that frequent stops for rest may be made. In some places old marshes that had been drained are being reflooded to produce the food and resting places that are needed. Many things are being done to aid the ducks, but the one important thing that is necessary to save the ducks has not been done. The shooting has not been stopped.

National and State parks have been created, in some of which no shooting is permitted. Yellowstone Park was one of the first great refuges for the persecuted animals and birds. No one can take a gun through the park unless the lock has been sealed by an officer. The rigid enforcement of this regulation has saved the buffalo, the elk, and many other wild creatures. Many large parks in the United States and Canada have been set aside where the wild things may not be molested.

Similar great reserves are found in other countries. Africa has several immense tracts of land where hunting is prohibited. Indeed, if you have an idea that you would like to go to Africa some day and shoot lions and elephants, you may as well give up the idea now. You cannot shoot such animals without permission from the government. Permits are issued to expeditions from museums to collect a



Keystone View Co., N. Y.

Deer being fed at a game preserve

specified number of certain animals, for example a male, a female, and a young lion. Only that number can be taken. You may go out, however, and see the lions and take their pictures, wild lions. But first you had better learn something about the habits of lions.

Private game preserves and bird sanctuaries are also appearing in our country. Some of these are not truly sanctuaries where animals and birds may not be shot. They are merely preserves which prohibit others than the owners from shooting. The animals are shot. Other preserves are truly sanctuaries where no shooting is allowed.

Often animals that are becoming scarce, come back very quickly when protected. In the State of Maine, beavers were in grave danger of extermination. Their trapping was prohibited, and now you may easily see beaver in the woods if you wait by their dams in the evening. Pennsylvania has had a similar experience and some other States that have protected the beaver have them again building their dams in the little streams. The fox is clever enough to get along with very little protection. Foxes are often common in farm lands close to the big cities. In some

areas of the East they are so plentiful that rabbits are scarce. Rabbits and field mice are the chief food of the foxes.

Protecting the wild flowers. Perhaps you have seen the beauty of meadows covered with wild flowers and have seen the exquisite beauty of some of our native orchids. If you have also seen roadsides high with dusty weeds, you will want the wild flowers back. Along the roadsides in some States you may see neat signs, "Do not pick the wild flowers. Let everyone enjoy them." In several States there are laws prohibiting the taking of certain kinds of flowers. Although generally such laws are poorly enforced, there have been prosecutions. It is popular demand rather than the law that will bring back the wild flowers as it brought back the bobwhites. Learn how beautiful the country may become with wild flowers. A wilted bunch of flowers gives little pleasure. Generally they soon wilt when gathered at the roadside by pleasure riders. At best they last a day or two indoors. In the field and meadow they may be worth a long journey to see.

If you want to pick wild flowers, take hardy flowers that are not harmed by taking a few blooms. Take daisies, buttercups, and violets. They are all as beautiful as the flowers of the garden. Picking them does not destroy the plants. The farmers would be glad if the daisies and the buttercups were destroyed, for they are weeds that take land that should be covered with grass. Do not take the orchids or the trailing arbutus. These beautiful plants have disappeared from large areas of country where they formerly grew. Learn the names of the wild flowers, and you will learn the flowers that are in danger of extermination. Take only those flowers that can take care of themselves.



Hugh Spencer, Chester, Conn. *Hugh Spencer, Chester, Conn.*

Dogwood and arbutus would soon be exterminated if they were not protected by State laws

Restocking the fresh waters. Bringing back the great numbers of fishes to our streams and lakes has not been so successful as bringing back the quail and deer. There are several reasons why we have not been so successful. One of these reasons is our ignorance of how a fish really lives.

Fish eggs are obtained from the fish and then cared for in tanks in the fish hatcheries. After the young fish hatch out, they are fed and protected in tanks until they get a good start in life. When they have reached the size at which they may have some chance of fighting their own battle of life, they are planted in streams. There they must protect themselves from their natural enemies. In some streams in the more settled parts of the country, rock jetties have been built to furnish pools in which the larger fish can retreat. The taking of fish is not permitted until they have reached a certain size. Fish caught below a certain size, which depends upon the kind of fish, must be returned to the water. The number that may be taken in a day is prescribed. Fishing is not permitted during the spawning (egg-laying) time.



Ewing Galloway, N. Y.

Fish hatched in fish hatcheries are emptied into the streams and lakes of many States

Many of our streams have been so polluted by sewage and industrial wastes that fish cannot live in them. We can never have fish again in the streams of our industrial regions or the regions of cities until both the poisonous industrial wastes and sewage are disposed of in other ways than turning them into streams. Oil and leakage from mines poison many streams. These evils can be corrected. Sewage disposal plants render the sewage harmless. Industrial waste also can be made harmless. It will be costly to protect the streams from these wastes, but the price must be paid for protection.

Aiding shellfish. The tons of salt-water clams and oysters taken each year have brought the necessity for some methods of preservation. Not very much has yet been done for the clams, although they are fast disappearing from some of the bays that formerly furnished a good supply. If they are not protected and helped, they may soon reach a state of dangerous exhaustion. Oysters have received better care. The Bureau of Fisheries takes active interest in them. Young oysters swim about freely when they are tiny, microscopic bits. Later they settle down. If they settle on something hard, they may live. If they settle in the mud they are smothered to death. Stakes, metal frames, concrete blocks or old oyster shells are spread on the bottom for them to settle on.

When they have attached themselves, the frames are moved to suitable places where the oysters grow to market size. Scallops, unprotected, have entirely disappeared from most of the former fishing grounds on the Atlantic coast.

Lobsters were so much in demand that they, too, seemed on the highroad to extinction, when the State and National governments took an interest and an active hand. Now lobsters under a certain size must be returned to the water. There are closed seasons during which no lobster may be taken. Lobster eggs are raised in hatcheries but the young lobsters are very difficult to raise. The problem of bringing back the former supply of lobsters has not been solved.

How to Study about Bringing Back the Wild Life

I. Read the chapter.

II. Study the preservation of wild life by observation and thought.

1. A good step to take in saving the birds is learning to name the birds. In the public libraries are usually books on birds. If you cannot go immediately into the field to study the birds, begin in the library. Get acquainted with the birds in pictures. You may be surprised how easily you can then name them in the field. Colored pictures of birds on cards may be bought rather cheaply and some have been given away as advertisements. You can develop quite a lively game with your classmates naming the birds.

2. Whether in the city or the country, try to bring the birds back, about your home, about the school, about the parks. Provide feeding stations and food. In the city make sure also to provide a drink, for water is not easy to find in the city when you cannot turn on a spigot. Build nesting boxes. If you have no place to set them up about your home or school, perhaps the park authorities will

arrange to have some good ones that you make set up in the parks. When you hike collect seeds and wild fruits and plant them on vacant spaces, not in the midst of a farmer's field, but in the waste spaces.

3. Learn from books in the library the food of common birds and make a chart large enough to show the class.

4. Watch what birds do and where they go. If you watch closely enough, you will find even English sparrows and starlings in the heart of the city have some interesting ways of solving the problems of getting along in the city. Report to the class what you see.

5. On a map of the United States, plot out the bird and wild animal sanctuaries. Learn what your State has done in providing such sanctuaries.

6. Make up some posters large enough to exhibit in your school hall that will help to educate people to protect the birds.

7. Learn the names of the wild flowers and fruits. Books will name the kinds you find.

8. Make up posters to educate the people as to which wild flowers should not be picked and which may be taken without danger of extinction.

9. If you are favorably situated, visit a fish hatchery and learn how fish are cared for. Tell the person in charge what school you are from and that you want to tell the class about the work. Take your camera along.

10. Try raising fish in an aquarium. Perhaps someone in the class is very familiar with the keeping of aquarium fish. Fish dealers will be glad to help you get an aquarium started in your schoolroom.

11. If you are situated near the coast, you can investigate the shellfish industry to learn whether it is improving or losing ground. What measures are being taken to improve the fishery?

12. If you are inland, you might learn something interesting by catching a crayfish with eggs and raising them until they grow to good size. The main thing to watch is the food, but they eat bits of meat freely.

III. Test yourself with these questions:

1. What are the general principles of bringing back animals that are becoming scarce? Mention some animals that have been brought back.

2. Why is it important that birds be protected? What should be done to protect the birds?

3. What is the government doing to protect the ducks? What more must be done?

4. How have other governments, as well as our own, protected wild animals?

5. What kinds of wild flowers should not be picked? What kinds may be picked without harm?

6. What measures does the government take to restock streams and lakes with fish? What more is needed?

7. What other water life is protected to some extent? How is it protected?

8. What kinds of valuable water life is not protected and is in danger of being seriously reduced?

IV. Think these out or investigate:

1. Why are lions and bears protected? Should wolves be protected?

2. Should snakes be protected? Your reasons?

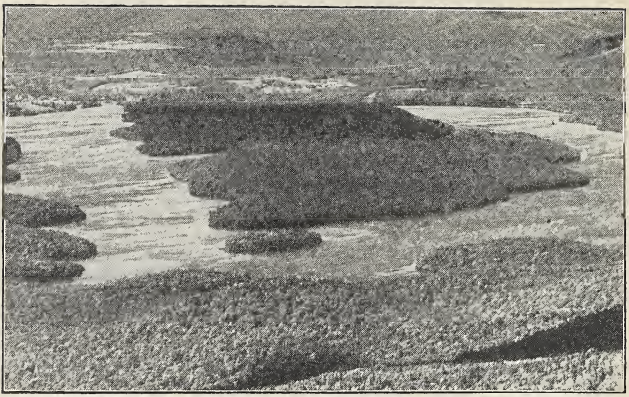
3. Consider the protection of insects. Are there any that should be protected? The reasons? What measures would be needed to protect them?

4. Quail, unprotected, were almost wiped out in many places. Mosquitoes that have been fought for ages are still numerous. Why?

5. The heath hen was a familiar bird to the New England settlers. They killed it for food. The last of these birds lived on the island of Nantucket. In spite of all protection in late years, they finally died out. Not a single bird is alive today. Can you suggest reasons?

6. Prairie chickens were very common when the settlers moved into the prairie States. Now they are gone from most of their former range. Why? What is the condition today?

V. Vocabulary. Have you any new words?



Philip D. Gendreau, N. Y.

CHAPTER FORTY-THREE

SAVING WATER AND FOREST

Do we need to save water? It may sound a little queer in some parts of our country to talk of saving rain. There is plenty of it there. In other parts of the country, however, rain is rare and precious. Even in regions of good rainfall, rain may fall in winter when crops are not growing and be lacking in summer when crops need it. Saving the rainfall is good economy. It is saving for a rainless day. Furthermore, too much rain coming all in a short time may mean great destruction by floods. We cannot stop the rain from falling in great quantities in a short time, but we can do a great deal to stop the water from running off quickly in great quantities that produce a flood.

How can we save water? The first place to start saving the fallen rain is at the place where it falls. If it falls on bare ground, it runs off quickly. If it falls on grass sod, very much less runs off. If it falls on forests, very little may run off. On the hills and mountains, therefore, forests are being saved and

new forests planted to replace those that have been cut down. You learned in the chapter on forests of some of the work of the National and State governments in caring for the forests. Many towns in several sections of the country also own forests along the watersheds which supply them with water. Water-power companies in many places own large forests in the hills and mountains from which flow the streams that furnish the power.

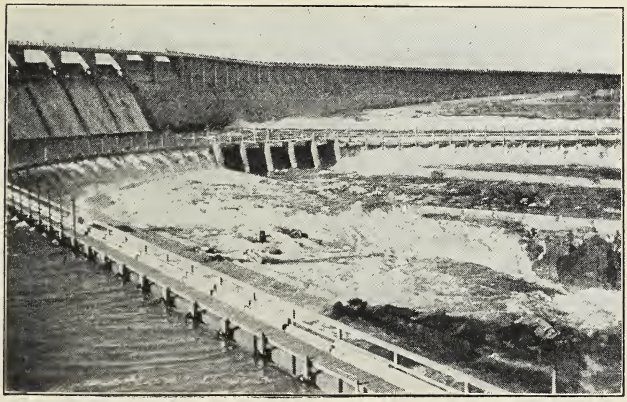
In addition to forests to hold the water on the ground or in it, there are works to hold the water in the streams and lakes instead of letting large quantities run away down the streams. Dams are built both on the small streams among the hills and on the larger rivers in the valleys. Dams are frequently built at the outlets of lakes to raise the level and store more water. In the drier season as the water is needed, the dam gates are opened and more of the stored water allowed to flow downstream. Great reservoirs have been built in several parts of the West for the storage of water. Boulder Dam in Arizona holds back the waters of the Colorado River in a great reservoir. The Grand Coulee Dam is being constructed on the Columbia River. In the Tennessee Valley the Wheeler, Norris, and other dams will regulate the flow of the Tennessee River. On many streams in the East and West, in the North and the South, dams have been built to create basins for the storage of water.

Along the Mississippi and its tributaries, where the great rivers have brought down great floods, there are other measures to reduce the destruction by floods. Levees are built to hold the flood waters in the channel. After the last great flood on the Mississippi, the National Government started work to raise the height of all the levees. This was a

major piece of work extending hundreds of miles. To protect levees from the river currents, aprons of brushwood or poles woven together with wires, concrete blocks, or rocks, are laid on the sides where the current flows. To carry off some of the water and so relieve the pressure downstream, spillways have been built to carry water out of the main river and lead it through other channels.

Many streams of the central part of the United States are navigable only when the water is high. The dams that help control the floods aid also in keeping open navigation during the dry seasons. Some of the dams are used to generate electric power. Other reservoirs are chiefly for irrigation. Cities have established large reservoirs behind dams, often at great distances from the city, to maintain the city water supply. All these various uses to which water may be put depend upon efficient methods of saving the water which falls as rain or as snow.

Saving and restoring the forest. Part of the problem of saving the water is saving the forest and restoring it to the land that has been stripped of its forest and is not used for other purposes. In the great National forests there are large stands of the original forest that have never been cut. Most State forests are on cut-over land. Some of this land is covered with small worthless trees or useless brush. More of it is bare earth and rocks. Where good trees are still growing, lumber may be taken out without destroying the forest. Trees that are to be cut and those that are to stand to produce more seed are selected by forest officers. The cut trees are removed without injury to those that are to remain. That is not the usual practice on large private land holdings where all trees that are not wanted immediately for the market are likely to be destroyed if they stand



Ewing Galloway, N. Y.

Floods are controlled and irrigation supplied by such dams as this

where they place the loggers at any inconvenience. Taking out the good trees and saving the forest where it stands is the purpose of the forester on the government forests and those privately owned where the owners are looking to future good as well as to the immediate money value.

Collecting tree seed. Where land has been cut over, the restoration of the forest is slow and expensive. If there is bare soil, young trees may be planted from the forest nurseries. Collecting the seeds to plant in the forest nurseries is an important work, and sometimes it is a dangerous work. Getting seed from the trees before it falls requires the climbing of forest trees and collecting the seeds and fruits. Getting forest seed is a very different and more difficult matter than picking fruit from orchard trees. In cone-bearing trees such as the pines and spruces, the cones are collected and brought to the forest stations. There the cones are placed in large cylinders which are slowly rotated while they are heated. The



Sally Pepper, Phila.

A pine cone with its winged seeds shown beneath it

heated cones dry and open, allowing the seeds to fall out. The seeds of these evergreens have wings on which they fly in the wind. These wings are broken off in machines to make the seeds more easy to handle. Seed gatherers often rob the hoards of squirrels that they find in hollow logs. Sometimes a half bushel of seeds may be found in one place hidden away by the squirrel when the harvest is good. In the forest, as in the orchard, there are good fruit years and poor fruit years. There are more poor years than good years. The seed collector and the forester must watch the developing seeds on the trees and take advantage of the good years.

The forest nursery. In the forest nursery the crop of young trees is as carefully tended as the farmer's crops in the field. The land is carefully prepared as garden beds are prepared. The soil is cultivated and its water-content is regulated. When the time and the soil are right, the seed is planted. When the seeds germinate, the young plants must be watched and guarded. Many kinds of young trees

cannot stand the hot, drying sun. Over such young trees lattice work of laths or similar light covering is built to give some shade. Too much shade however, kills most young trees. Certain kinds of trees, like maples and spruces, can endure deep shade, but most trees must have some sun but not too much. Later in their growth when the young trees are strong and have developed good roots which enable them to feed well on the mineral water of the soil, the shade is removed. The young trees are several years old when they are ready to be moved from the nursery to the land where they are to grow into forest.

Forest enemies. Enemies of trees, young and old, live in the forest. Mice, rats, and ground squirrels feed upon the seeds. Birds of several kinds also eat the seeds. Squirrels eat the seeds and collect the seed, either hiding them in roots and hollow logs or burying them in the ground. This work of the squirrels is not all evil, for probably many of the hidden nuts are not dug up again. Such nuts are buried at just about the depth for good planting. Squirrels may thus aid the forester. Seldom is an animal all good or all evil. It is unwise to pronounce any wild creature a friend or an enemy until there has been thorough study of the life of the creature. When the number of rats, mice, and ground squirrels in a forest is large, it has been found by actual study that they may devour practically all the seed, leaving too little to replenish the forest. Rabbits may be very destructive to young



Hugh Spencer, Chester, Conn.

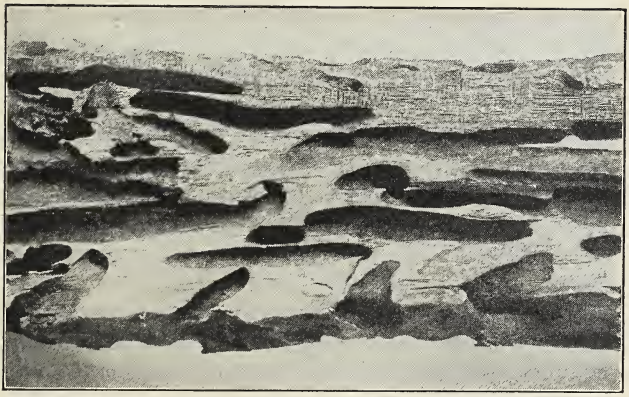
Tent caterpillars' nest

trees when long snows cover the ground. Then the rabbits gnaw the bark for food.

More serious than the rats, mice, and ground squirrels are much smaller animals, the insects. A large number of different kinds of insects attack trees. Some feed upon the leaves, others upon the young buds, and others bore into the wood. You have probably seen the tent caterpillars that build unsightly nests of dirty silk in the twigs. They come forth from these nests to devour the leaves and retreat to them again for rest. Often trees are stripped bare of their leaves by these caterpillars. More destructive to the forest trees are the caterpillars of the gypsy and browntail moths. Whole forests may be stripped of their leaves by these greedy caterpillars. You perhaps have seen wood riddled by holes. These holes are due usually to the young or larvae of wood-boring beetles.

Fighting insects. In fighting the various destructive insects, the forester uses both chemical poisons and the natural enemies of the insects. Insect-eating birds are very valuable aids in keeping down the numbers of the destructive insects. Indeed, it is chiefly due to birds that the insects do not destroy almost everything that grows on the land. Ceaselessly the birds kill insects. Their lives depend upon it. Insects are their food and they must find insects or starve. Vast numbers of birds are busy day after day hunting insects on the twigs and leaves, on the trunks and in the ground. A person who shoots an insect-eating bird does a great harm.

The forester also uses insects to fight insects. Scientists who study insects hunt out the insect-enemies of the destructive insects. The gypsy moth came to us from Europe. To Europe went the insect-men to find the enemies of the moth there.



Hugh Spencer, Chester, Conn.

Wood riddled by borers

Among others they found kinds of beetles that fed upon the caterpillars of the gypsy moth. These beetles have been brought to the United States to fight the moth. The beetles have been said to be the most important means of bringing the gypsy moth under control in New England where it was destroying whole forests.

Spraying poisons upon forest trees is more difficult than spraying orchard trees. Spraying from airplanes has been tried over forests, and in some instances it has been successful in stopping outbreaks of insects. However, the forester relies more upon the natural enemies of the injurious insects than upon chemical poisons to keep them under control.

Diseases of trees. Diseases also kill trees young and old. The chestnut blight wiped out the chestnut trees of the Eastern States. The white pine blister rust threatened to kill all the white pines. The Dutch elm disease is spreading rapidly and killing the elms. There are many other diseases that attack the forest trees and the shade trees. Against some

of these diseases the forester has no better remedy than to find the diseased trees, cut them down, and burn them to prevent the spread of the disease to other trees.

Control of fire. If you have traveled in forested regions you probably have seen the lookout towers standing on high hills. In these towers men are stationed to watch for smoke rising over the forest.

Fire rangers with small portable radios are used in many of the large forests. They can make an immediate report to the chief telling the nature of a fire and the supplies and men needed. Airplanes are used to patrol for fire and to investigate the fire that has been reported. In the lake country airplanes are used to take fire fighters in close to the fire. In country without lakes, trails must be used, and the fire may make terrific headway before the fire fighters reach the scene of action. Trails are built and kept in condition for carrying in apparatus and supplies. The Civilian Conservation Corps under the direction of the Forestry Service has built hundred of miles of such trails.

The apparatus used to fight forest fires depends upon the location of the fire. If pumps can be taken in, the fighting is simplified. Small gasoline pumps can be carried by airplane or on pack horse. Hand pumps and tanks are strapped to the backs of men. Shovels, rakes, and axes are other tools necessary.

In general, the plan of fighting the fire is to clear a strip of land across which the fire cannot spread and then to put out with dirt or water the burning leaves and brush. If there is no wind, and the fire is burning chiefly on the ground, a small lane a foot wide raked bare of dead leaves and sticks may stop the advance. If the fire is burning in the crowns of the trees with a wind to fan it, it may burn hundreds

of miles until it reaches a mountain ridge which it cannot cross or a lake. Fire lanes kept clear of vegetation are maintained to stop the spread.

The best control of fire is prevention of its starting. Along roads through forests you often see signs fastened to the trees warning you not to light fires. In some forests there are heavy fines for lighting fires without the permission of the fire warden. In others regular picnic and camping places are provided where fires may be lighted in fireplaces built for the purpose. Signs warning woodsmen not to smoke as they walk through the forest are sometimes seen. Motorists are warned not to throw lighted cigar stumps from car windows. Narrow roads are frequently bordered by cleared stretches which are less likely to start fires if the motorist disregards the warning not to throw out cigar stumps. The reduction of fires in many States shows that education and vigilance can correct the evil of forest fires.

How to Study about Saving Water and Forest

I. Read the chapter.

II. Study saving water and forests by observation.

1. If you go afield during rain or immediately after, you may easily see whether more rain runs off forest, grass field, or bare ground.

2. Study the pictures of dams to determine, if possible, why the dams were located as they were. Study the maps of the regions to determine, if possible, where the water falls as rain and what uses might be made of the stored water. Are there sufficient towns and cities within two hundred miles to utilize the power? Does the land need irrigation? Can it be used for city water supply? What was the primary purpose in building the dam?

3. Visit forests and wood lots. Is the forest natural growth or planted forest? For what purpose is it used? In removing trees was care taken to leave seed trees? Are

there young trees growing up? Are they of the same kind as the tall trees? How would the land be affected if the forest were cleared? From the location is it likely that removal would be followed by erosion of the soil?

4. Collect seeds of all the trees that you can. If you were collecting to plant in a forest nursery, could plenty of seed be easily secured?

5. If possible visit a nursery, either a forest nursery or one in which trees are grown for shade and ornamental purposes. Learn the kinds of trees; how seed was secured; how the seed was stored and planted; how the beds were prepared; at what age the trees are removed for use elsewhere.

6. As you hike, make a study of enemies of the woods. Collect specimens of injurious insects. Study the shade trees. Are they suffering from any cause? Do you see any evidence that cattle and sheep or hogs have damaged the woods?

7. How are trees sprayed? Make a study of trees in your neighborhood to learn for what and with what they are sprayed. Include in your study forest, shade trees, and orchard trees.

8. Have you seen any forest fire service? Have you seen forests that have been damaged by fires? Were the trees, young and old, all killed? Did the forest come back again? Did the same kinds of trees grow before the fire as after the fire? If there is any difference, can you account for it? If you can visit a fire tower, go up in it and talk to the lookout man. He will be glad to see you and tell you how he locates fires and how they are fought.

9. How have fires been started in forests that you have visited? Did you see any fire hazards (risks)? How could they be removed?

10. If you wanted to light a fire in the woods and wanted to be sure that there would be no danger to the forest, how would you proceed?

III. Test yourself with these questions:

1. Write down a list of purposes for which water is saved by storage. How is water stored on a large scale?

2. Besides storage, what other precautions are necessary to make sure that there will be ample supply of water in dry season?

3. What precautions are taken to prevent damage by flood?

4. What have forests to do with water supply?

5. How are forests destroyed?

6. To save a forest but get out the wood, what precautions are taken?

7. From the collection of the seed onward, tell how forests are secured on land that has none.

8. Write down a list of forest enemies. Tell how each may be combatted. Tell several measures used in combatting insects.

9. How is fire in the forest fought?

IV. Think out or investigate:

1. Dams for water storage have been built recently in many parts of New England. Why? Look up on the map the location of dams in the West. Why were they built?

2. Do you know of any substitutes for wood? Do you know of any substitute for the forest on the watershed as a protection to the water supply?

3. Do you suppose that floods are better or worse now than before the white man came to America? Why? That is not an easy question to answer without argument. Do they have floods on the Amazon and the Congo, both of which flow through heavily forested country?

4. Here is one that foresters and weathermen have argued about: Will planting forests increase the rainfall?

V. Vocabulary. Did you find anything new?



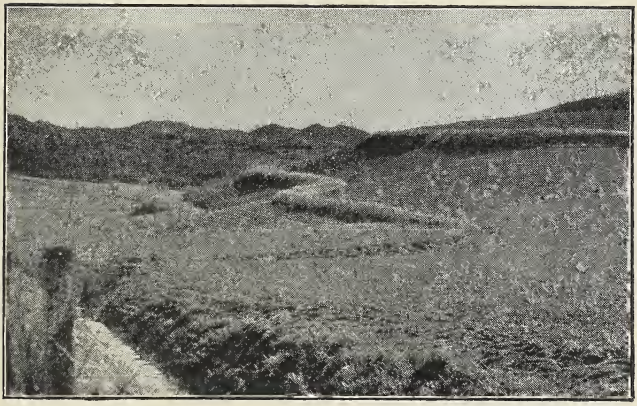
U. S. Soil Conservation Service

CHAPTER FORTY-FOUR

SAVING SOILS AND MINERALS

Losing the soils. Government officials are much worried because our soil is running away, but most farmers are not worried. Farmers realize that certain fields that they have seen have lost the good topsoil and are worn down to the barren subsoil, but they often do not realize that methods of farming they are using allows their own good topsoil to flow off in the muddy water of each heavy rain. At least many farmers do not do anything about it. They just let the good fertile soil run away downhill and do not change their farming to stop the loss. Great rain gullies develop on the hill farms. These gullies dig down to the subsoil that produces nothing. The gullies grow from year to year, if measures are not taken to stop them. The end of it all is the loss of the farm.

The government is sufficiently worried to pay men to fill gullies on certain farms whose owners agree to co-operate with the government in saving the soil. The Civilian Conservation Corps have built check



U. S. Soil Conservation Service

Terraced fields help prevent erosion

dams across field gullies to hold the soil that is washing away. Good farmers do not let gullies grow. When a gully starts they put in brush to hold the soil. The best farmers do not let gullies start. That step may necessitate giving up a part or all of a field on a steep slope where gullies form. Sometimes the farmer feels that he cannot afford to lose the profit from a field. If he keeps on farming it, however, in the end he may lose the field when its fertile soil is taken away by the rain wash. Very often that loss can be easily stopped by changing the kind of crop on a field that gullies easily. Thus corn on the hill may be replaced by pasture or by small grain. Corn is cultivated during the growing period and the soil is left bare by planting the corn far apart. Wheat and the small grains, on the other hand, grow so densely that little bare soil is left for the rain to wash easily away.

Mountainsides in the Philippines are terraced to provide flat fields. The ancient Indians of the Inca

days in Peru also terraced the mountainsides to hold the soil in their fields. Terraces are used in many other parts of the world. On mountainsides in the United States, however, steep slopes are cleared and farmed just as they are by farmers who know that in three to five years the soil will wash down the mountainside. Then they expect to clear some more mountainside and let the soil again run downhill. The government soil service is anxious to stop that kind of farming. The high, steep slopes should be kept in woods. Slopes less steep may be kept in sod for pasture. More gentle slopes may be used for growing small grains and the most level land for corn and tobacco and cotton. These lands on the steep mountainsides are classed as "marginal lands." The government is anxious to move the farmers off these lands and settle them on better farm lands. The problem of finding sufficiently good farm lands, however, has not been solved.

Losing our minerals. The resources under the soil are also a matter of concern to the government and to others who look far ahead. Our mineral wealth comes from the ground. Those countries that do not have rich mineral resources must always be poor industrial countries unless they find a way of getting the minerals satisfactorily from abroad. Modern wars are fought for possession of resources lacking in the aggressor country. Every country wants to have a supply of minerals that will support it if it is cut off by war from its foreign supply. The United States is very rich in mineral supplies. Certain supplies, however, are lacking or are meager in this country. We have no tin, and we use it in large quantities. Think of all the tin cans. They are really iron cans coated with tin, but the coating uses a great deal of tin. Most of our supply comes from



U. S. Soil Conservation Service

Small dams check erosion and fill gullies

Malaysia, on the other side of the earth. We produce zinc and copper, but not enough. We import large supplies. We produce aluminum, but import large quantities. Many other minerals are imported into the United States. Many of the minerals could be saved for the future emergency by using other materials. Galvanized iron which is iron coated with zinc might be replaced on roofs by asphalt. Tin foil wrappings might usually be replaced by paraffin paper or cellophane. We have large supplies of asphalt and paraffin, yet they, too, are threatened. Indeed the material from which both are prepared, petroleum, is a matter of grave concern.

Wasting oil. At the rate petroleum is being used and wasted in the United States, it will not last long. How long the oil wells will pump oil has been variously estimated from ten to fifty years. So important has oil become that the government has set aside oil reserves that are not pumped for present use. Oil is largely used in place of coal in warships, and oil yields the gasoline for airplane fuel. Because of its convenience, oil is replacing coal in homes and industry. Automobiles in ever-increasing numbers are

traveling the highways. The gasoline which drives them comes from oil. Oil is necessary for lubrication. The modern world does its work by machinery, and machinery must have lubrication. Oil has been carried to the North Pole and to the South Pole, and it is regularly imported into the jungles and the deserts.

Waste in the production and use of oil has alarmed the far-seeing officials of the government. In drilling for oil there is waste. Each property owner or company is anxious to get his share of the oil before it is pumped out. Therefore many wells are drilled into the pool of oil below the surface and all pump as fast as they can to get their share before the pool fails. The pool must fail, for it is formed by the oil that has collected in one place under layers of rock through which it cannot pass. New pools are still being discovered in the United States, but there must be an end. Some of the waste might be stopped by agreement or by government regulation of the drilling of wells and the pumping from each pool.

When the pools of oil are exhausted, there is another source of oil in our country not at present used. Certain kinds of shale contain oil within the rock. This shale can be crushed and the oil extracted. Oil has been extracted from shale in Europe. Oil from shale will not compete with oil from oil pools so long as the pools last. There are great deposits of oil shale in the West. These deposits are not inexhaustible. They may last for a few centuries. Gasoline may be extracted from coal, but coal will probably give out before the oil shale.

Wasting gas. With oil, natural gas is found. At present, and in the past, this valuable fuel has been largely wasted. Gas pipes leading into the wells were lighted and allowed to burn away just to get

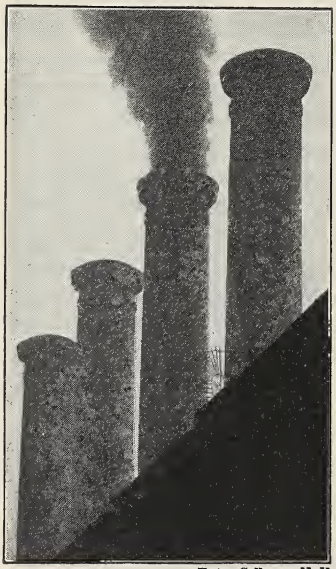
rid of it. This gas is valuable fuel, much more efficient fuel than the gas manufactured from coal in the cities. Unfortunately the gas from a well is often soon exhausted. Towns, cities, and industries which have been served with natural gas have found themselves rather suddenly without any gas. There seems at present no way of telling whether gas will last a long time from a well or only a short time. The spending of money to lay gas pipes and the erection of factories in the gas region are therefore risky investments. No cheap way of storing gas in large enough quantities to make it profitable has been discovered. Therefore, this excellent fuel is largely wasted. There is no way in sight at present of stopping this large-scale waste.

Wasting good coal. Even coal, still the most valuable and widespread industrial fuel, is being wasted. Half of our coal is wasted in getting it out of the ground. A ton of hard coal is wasted for each ton shipped from the mines. There is only a relatively small quantity of hard, or *anthracite*, coal in the world. Eastern Pennsylvania is the greatest center. Half of the supply has already been mined. We have a much larger supply of soft, or *bituminous*, coal. Most of the coal of industry is bituminous. It is much cheaper than anthracite, but for use in the homes it is not so convenient. A poorer grade of coal is brown coal, or *lignite*. Under the Great Plains there are great supplies of lignite. This is used in some localities. When the better grades of coal are exhausted or seriously reduced, lignite will be mined and used extensively.

Stopping the fuel waste. A few centuries hence, the coal and oil of the United States will probably be exhausted. If all waste could be stopped, it would last longer. Some of this waste can be stopped by

government regulation preventing the unwise extraction from the ground. Without this regulation, each producer is anxious to get all profit possible while there is fuel below ground and the market is good. Competition too often means waste of our natural resources. There is a steadily growing feeling among officials and among the people at large that natural resources which cannot be replaced should not be wasted by present competitive practices.

Another important source of waste is found in our inefficient engines and heating plants. An automobile uses about one fifth of the fuel and wastes four fifths. An ordinary steam engine gets only about one tenth of the heat out of a ton of coal. The other nine tenths are wasted. The best steam engines get one fifth and waste four fifths. The waste of the heating plants in our homes is probably much greater. Far the larger part of the heating power of our coal and oil is lost. Thirty per cent goes up the chimney unused. The great clouds of smoke that you see hanging over cities show lost fuel. If you have lived in cities, you are aware that black dust settles everywhere. Buildings, trees, and even faces are blackened. At the close of a day's business, the city man or woman can wipe



Ewing Galloway, N. Y.

Smoke shows lost fuel

a heavy coating of black from the face. That is one thing that is the matter with city complexions. The black stuff is carbon, the black stuff of coal. It is floating in the air because the furnaces and engines did not burn it up. Scientists and engineers can improve engines and furnaces, and perhaps it will be possible to instruct people how to fire their furnaces so that most of the heat is not lost. Or furnaces in homes may be made automatic to a large degree so that the firing will be in the hands of experts. We have automatic oil furnaces today, but unfortunately they are not designed to save fuel.

How to Learn about Saving Soils and Minerals

I. Read the chapter.

II. Study by observation conservation of soil and minerals.

1. What evidence have you seen that our soils are washing away? Study fields and hills. Study pictures that show what rain does to hillside farms.

2. From observation of hillsides and from picture study, answer the following:

What evidence do you see that certain crops or certain uses of land lead to the washing away of the soil? What evidence do you see that other crops protect the soil? What kind of crops endanger the soil on steep hillsides? What kinds of crops should be used on hillsides? What use would be made of the steepest hillsides?

3. Make a list of the metals and other mineral products that you meet in a day. Learn in the library where each is produced. Which are we short of in this country?

4. Note all the uses of oil that you can observe in a day. Remember that all machinery is lubricated with oil. Where does the oil come from?

5. Note all smoke that you see in a day. Remember that all coal smoke is waste.

6. Study the firing of your furnace. Learn how you can regulate the draft to get the most heat from the coal that is burned.

7. Loss of heat that is produced for the heating of buildings or of boilers is loss of fuel. Make a study of your home and of your school to learn how heat is lost. Can this loss be reduced without causing other serious conditions, such as poor ventilation?

8. Scrap iron is bought to be used over again. For what is it used? Write down in your notebook an estimate of waste metal that you have observed in a day or in a week. Can this waste be stopped?

III. Test yourself with these questions:

1. What evidence do you have that soil is being lost from our fields?

2. What measures will stop the loss or most of it?

3. What minerals are constantly lost in large quantities?

4. What measure will stop some of this loss?

5. What substitutes can be used for metals in many instances?

6. How does the chief loss of oil occur? How can it be stopped?

7. Why is natural gas largely wasted?

8. How is coal wasted? What may be done to stop much of the waste of coal?

IV. Think out the answers to these questions or investigate:

1. If the fields on the steep hillsides are no longer used to farm, will our food supply be seriously reduced? Your reasons?

2. The United States Government has prohibited the sale of the gas helium in the country without government permission. Why?

3. Alcohol is a fuel. Is there as much danger that our supply of alcohol will be exhausted as that of our oil supply will be exhausted? Your reasons?

4. Are there any substitutes for petroleum for use as fuel and for lubrication?

V. Vocabulary. Have you any words to add?

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